Late Ordovician Strophomenide and Pentameride Brachiopods from Central New South Wales

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Strophomenide and pentameride brachiopods are described from shelfal environments (BA 3) flanking islands of the Macquarie Arc during the Late Ordovician (latest Sandbian to early Katian stages). Most of the strophomenoid genera recognized are new, monotypic, and hence endemic, although the occurrence of a new species of *Shlyginia* is indicative of affinities with Kazakhstan. Taxa described include the strophomenid *Geniculomena barnesi* gen. et sp. nov., the rafinesquinid *Testaprica rhodesi* gen. et sp. nov., glyptomenids *Resupinsculpta cuprafodina* gen. et sp. nov., *Paromalomena zheni* sp. nov., and *Platymena*? sp., and the plectambonitoid *Shlyginia rectangularis* sp. nov. Review of the generic assignment of *Oepikina*? *walliensis* Percival, 1991 suggests that this species is better placed in *Murinella* Cooper, 1956. Relatively rare pentameride brachiopods are represented by only a few specimens, including an unnamed species of *Parastrophina*, and a species tentatively referred to *Eoanastrophia*.

Manuscript received 1 December 2008, accepted for publication 16 February 2009.

KEYWORDS: brachiopod, Late Ordovician, Macquarie Arc, new genera, pentameride, strophomenide

INTRODUCTION

Late Ordovician strophomenide brachiopods are well-represented in limestones and sandstones deposited around volcanic islands forming the Macquarie Arc in central New South Wales, with most of the fauna having previously been described over the past three decades (Percival 1979a, 1979b, 1991; Percival et al. 2001). For various reasons (including rarity of specimens, and insufficient knowledge of morphological features needed to characterize new species), several additional strophomenide taxa have remained undocumented. This paper aims to address this deficiency in order to present a more complete picture of the fauna to underpin future analyses of biogeographic relationships. In addition, species of Late Ordovician strophomenides previously tentatively ascribed to *Oepikina* by Percival (1979b) from the vicinity of Gunningbland, and Percival (1991) from the Licking Hole Creek area, near Cliefden Caves (Figure 1), are reassessed in order to clarify their systematic position.

The opportunity is also taken to describe some rare examples (represented by just a handful of specimens) of Late Ordovician pentameride brachiopods. Both genera recognized are left in open nomenclature as all specimens are incomplete. However, the presence in the fauna of two additional camerelloids is significant and worthy of documentation as only one species of pentameride brachiopod, *Didymelasma inconspicua* Percival, 1991, had previously been described from contemporaneous rocks of the region.

Except for specimens of *Testaprica rhodesi* gen. et sp. nov. and *Platymena*? sp. which were found in fine-grained sandstone in the upper Gunningbland Formation of late Eastonian (Ea3-4) age, the brachiopods described here are silicified, having been recovered from residues of limestones dissolved in dilute hydrochloric acid. These limestones are of early Eastonian age, equivalent to the latest Sandbian or earliest Katian of international usage. Details of the stratigraphic succession and tectonic context within the Macquarie Arc in central NSW are provided by Percival and Glen (2007), and only a brief summary of the age and correlation of these strata (Figure 2) is given here.

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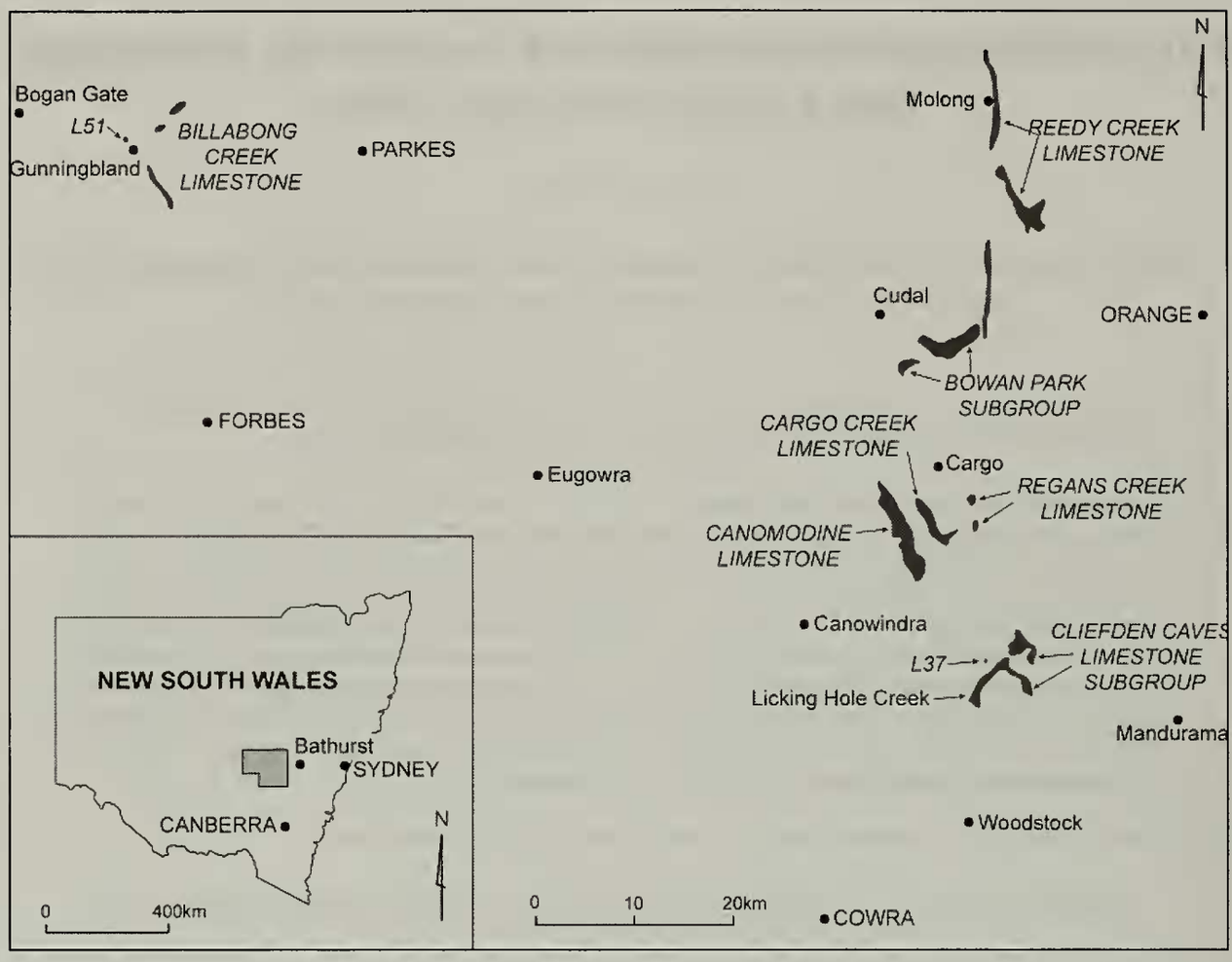


Figure 1. Locality map showing sites in central New South Wales yielding Late Ordovician brachiopods described in this paper. Outcrop of main Upper Ordovician limestone units shown in black; localities (L37, L51) in overlying Upper Ordovician clastic-dominated units are shown by spots.

Stratigraphic setting

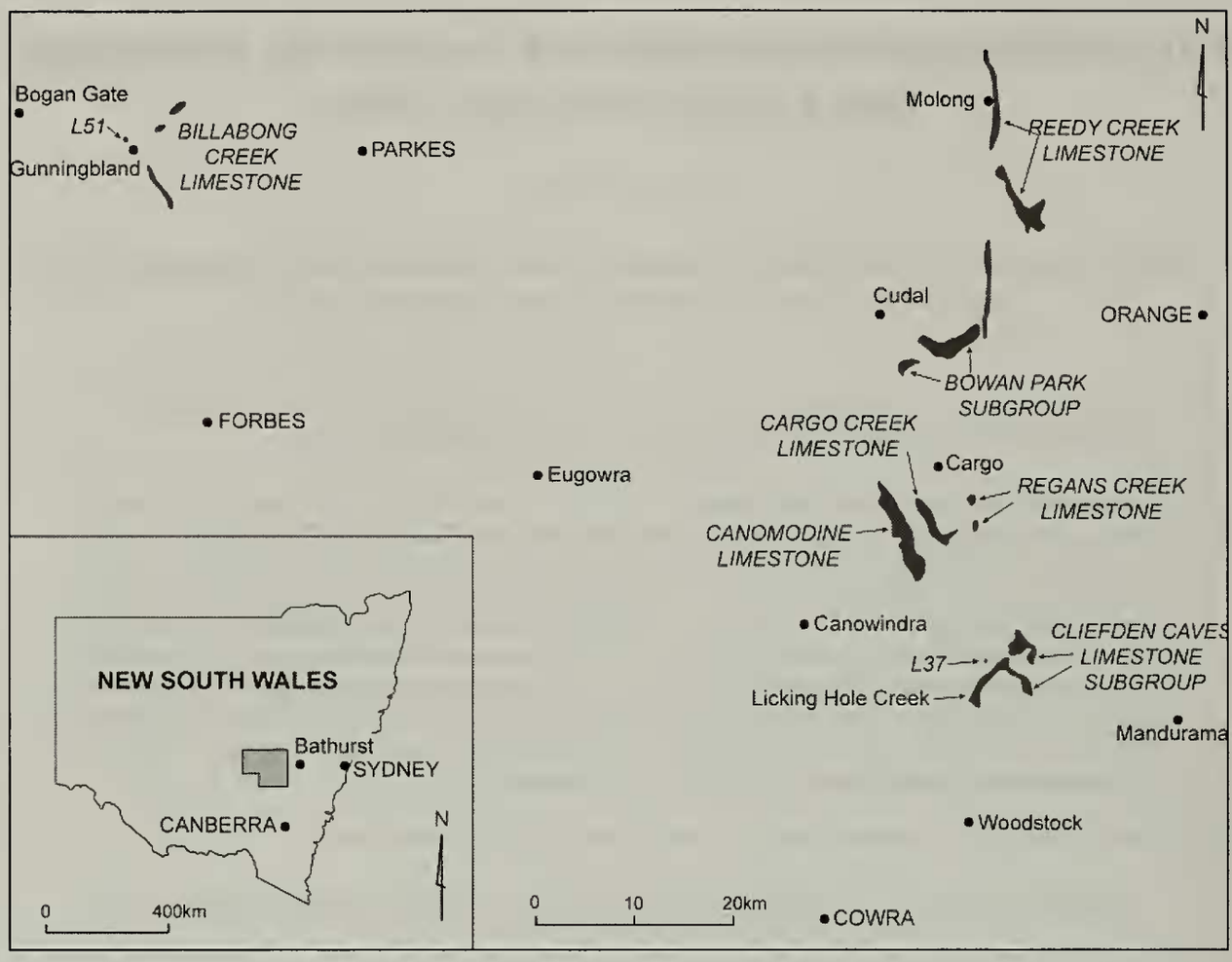
Cliefden Caves and Licking Hole Creek areas, east flank of Molong Volcanic Belt

In the Cliefden Caves area of central New South Wales (Webby and Packham 1982) and the Licking Hole Creek area adjacent to the west (Percival 1976), a well preserved Late Ordovician carbonate-dominated sedimentary succession formed on an eroded volcanic island setting, represented by the Walli Volcanics. The Cliefden Caves Limestone Subgroup includes the Fossil Hill Limestone at the base, succeeded by the massive Belubula Limestone which is itself overlain by the Vandon Limestone. Biostratigraphic evidence from conodonts, trilobites, corals and stromatoporoids, and brachiopods, demonstrates that the Fossil Hill Limestone (and equivalents in the Licking Hole Creek area), and the lower part of the Belubula Limestone, were deposited in the earliest Eastonian (Ea1); the remainder of the limestone succession is of Eastonian 2 age, which corresponds to the basal Katian stage.

The strophomenide biofacies characterizes Benthic Assemblage 3 (BA 3) throughout these limestone deposits, which is interpreted as occupying open shelf environments in well-circulated shallow to moderate water depths (Percival and Webby 1996). Representative brachiopods of this biofacies have been largely documented by Percival (1991); further species described herein include *Geniculomena barnesi*, *Resupinsculpta cuprafodina*, *Paromalomena zheni*, *Shlyginia rectangularis*, and *Parastrophina* sp. Additionally *Oepikina walliensis* Percival, 1991, described from the basal Belubula Limestone in the Licking Hole Creek area, is reassessed and assigned to *Murinella*.

Regans Creek Limestone, southeast of Cargo, east flank of Molong Volcanic Belt

The Regans Creek Limestone, mapped by McLean (1974), is a relatively small exposure of limestone that is contemporaneous with the Cliefden Caves Limestone Subgroup.



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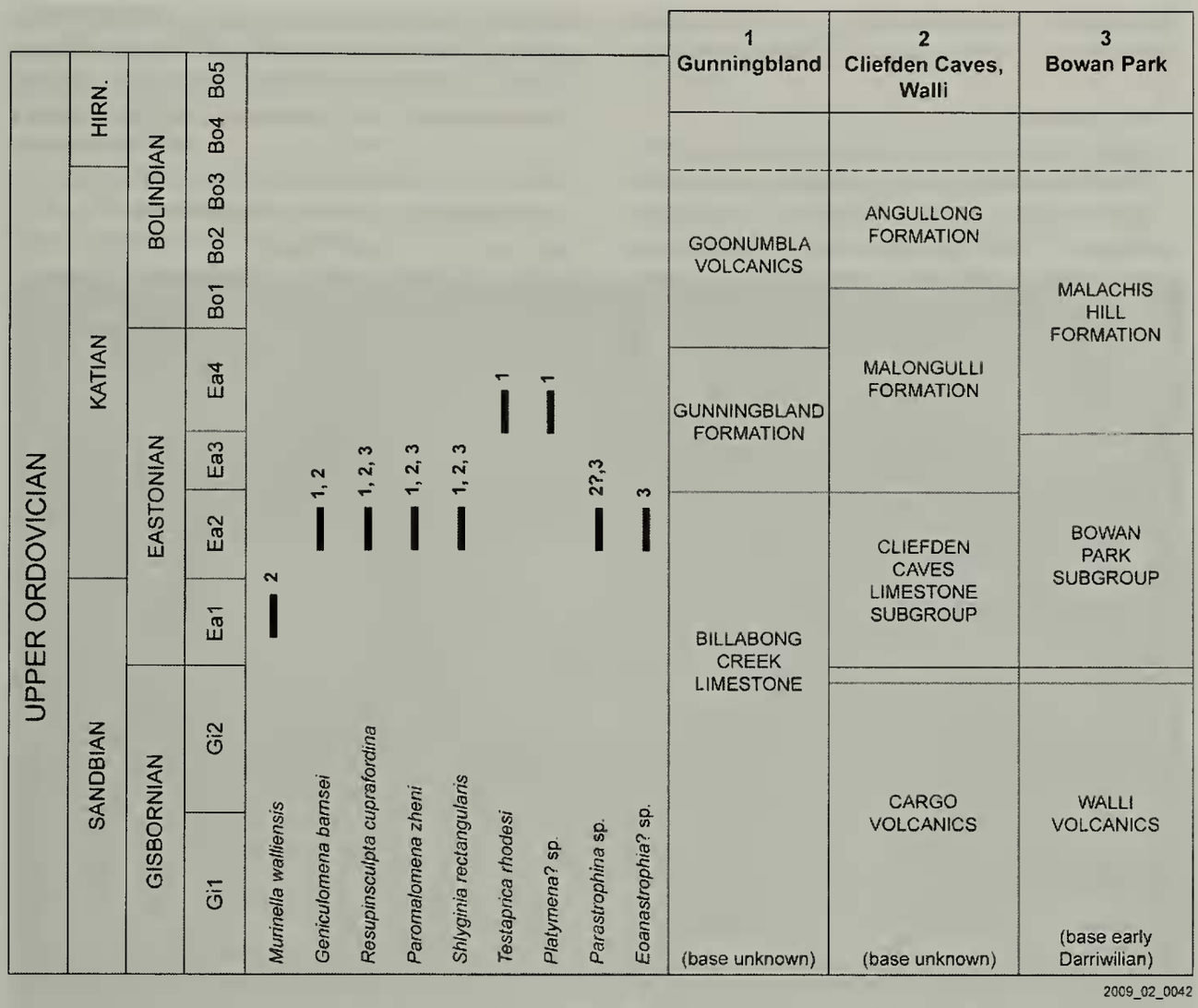


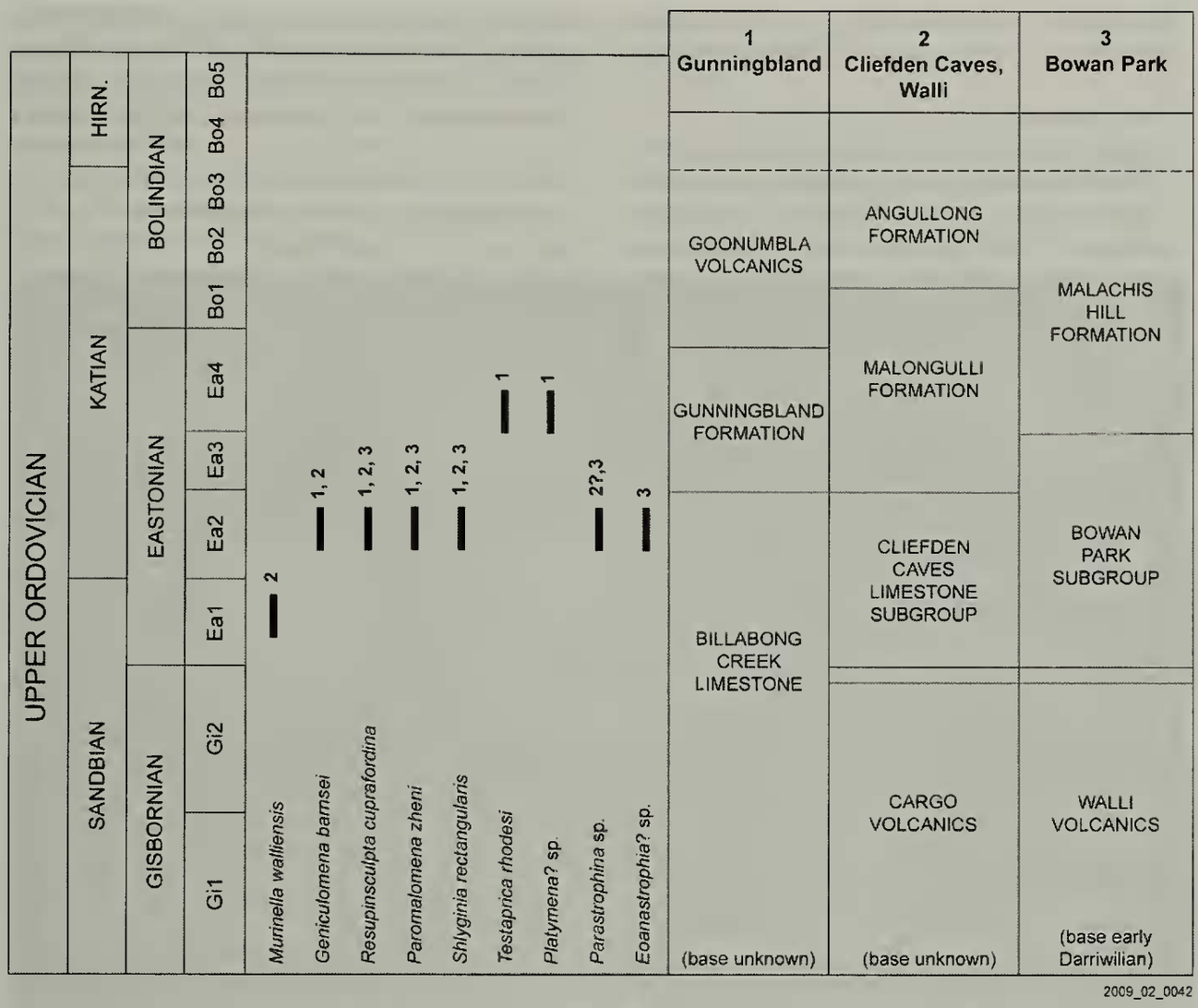
Figure 2. Stratigraphic levels at which Late Ordovician brachiopods described in this paper occur in central New South Wales. Numerals associated with approximate ranges refer to numbered stratigraphic columns to the right. Note that *Parastrophina* sp. also occurs in the Checkers Member in the upper Regans Creek Limestone (not shown on this diagram). HIRN. = Hirnantian stage.

The Checkers Member in the upper part of the Regans Creek Limestone yields a silicified fauna comparable to that in the Trilobite Hill Limestone Member of the Vandon Limestone at Cliefden Caves, although diversities are considerably lower. To the brachiopods described from this level by Percival (1991) can now be added *Parastrophina* sp.

Bowan Park area, west flank of Molong Volcanic Belt

The geology of the Bowan Park area has been described in detail by Semeniuk (1970, 1973). Limestones of the Bowan Park Subgroup (including in ascending order, the Daylesford Limestone, Quondong Limestone, and Ballingoole Limestone) overlie the Cargo Volcanics, and are in turn overlain by the Malachis Hill Formation (Fig. 2). The succession at Bowan Park differs from that on the southwestern MVB (in the Cliefden Caves area) where late Eastonian (Ea3) age sediments are represented by the graptolitic Malongulli Formation above the Cliefden Caves Limestone Subgroup, whereas carbonate deposition (Ballingoole Limestone) occupied this interval in the Bowan Park area.

The Quondong Limestone contains abundant marine invertebrate faunas of the strophomenide biofacies (Percival 1991), comparable in age and diversity with those in the Trilobite Hill Member of the Vandon Limestone (Cliefden Caves Limestone Subgroup) and like that unit clearly belongs to BA 3 (i.e. shelfal). Additional species described herein from the Quondong Limestone include *Resupinsculpta*



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cuprafodina, *Paromalomena zheni*, *Shlyginia rectangularis*, *Parastrophina* sp. and *Eoanastrophia*? sp.

Gunningbland area, Junee-Narromine Volcanic Belt

The Billabong Creek Limestone was shown by Pickett and Percival (2001) to extend from southeast of Gunningbland in a broad arcuate band trending northwestwards to north of the Parkes-Broken Hill railway, then northeast to exposures on "Kirkup" property (Figure 1). Conodonts from the "Kirkup" section, of early Darriwilian (Da2) age (Zhen and Pickett 2008), are the oldest dated fossils in the Billabong Creek Limestone. Younger conodont and coral assemblages from the type section of the formation on "Nelungaloo" property, southeast of Gunningbland, range in age through the late Darriwilian, Gisbornian and earliest Eastonian (Pickett and Percival 2001). Outcrops in and adjacent to Billabong Creek at the southern extremity of the limestone belt are rich in silicified fossils, particularly brachiopods (including *Geniculomena barnesi*, *Resupinsculpta cuprafodina*, *Paromalomena zheni* and *Shlyginia rectangularis*, described herein, and a diverse fauna documented by Percival 1991) and trilobites (Webby 1973, 1974), of Eastonian 2 age (Pickett and Percival 2001). These upper beds of the Billabong Creek Limestone correlate with the Quondong Limestone at Bowan Park, and the Trilobite Hill Limestone Member of the Vandon Limestone in the Cliefden Caves Limestone Subgroup (Figure 2).

The Billabong Creek Limestone is apparently conformably overlain by the Gunningbland Formation, although the actual boundary is unexposed. The outcrop belt of the Gunningbland Formation consistently lies immediately west of the arcuate trend of the Billabong Creek Limestone exposures (Pickett and Percival 2001). Shallow excavations and exposures in ploughed fields on "Currajong Park", "Sunnyside" and "New Durran" properties in the Gunningbland district reveal that the Gunningbland Formation predominantly consists of siltstone, shale, and fine- to medium-grained sandstone, together with minor fossiliferous limestones.

Most of the Gunningbland Formation is of late Eastonian (Ea3) age, determined from graptolites in siltstones, and conodonts including *Taoqupognathus tumidus* in limestone lenses. The limestones also contain a coral-stromatoporoid assemblage corresponding to the contemporaneous Fauna III (McLean and Webby 1976, Webby and Morris 1976). Two brachiopod faunas, elements of which were described by Percival (1978, 1979a, 1979b), are recognised. Brachiopod Fauna C, of Ea3 age, is present in the lower part of the formation on "New Durran" property. The presumed latest Eastonian age of Fauna D (Percival 1992), occurring in strata on "Currajong Park" property, was confirmed by the presence of graptolites of Ea4 age in the uppermost beds of this section (Pickett and Percival 2001). A diverse trilobite fauna has recently been described from this upper part of the unit (Edgecombe and Webby 2006, 2007), associated with the brachiopods *Testaprica rhodesi* gen. et sp. nov. and *Platymena*? sp. which are documented herein. This completes description of the brachiopod fauna collected from the Gunningbland Formation over more than three decades; two other genera (*Christiania* sp., *Ptychopleurella*? sp.) are represented in the upper part of this unit by single specimens of ventral valves, which do not warrant description until further material is forthcoming.

Systematic palaeontology

Type material (designated MMF), comprising specimens described and illustrated or listed herein, is curated in the palaeontological collections of the Geological Survey of New South Wales held at Londonderry in western Sydney. Some specimens labeled SUP, including material of *Murinella walliensis* and an external mould of the ventral valve of *Testaprica rhodesi*, were transferred from the Geology Department of the University of Sydney to the Australian Museum, Sydney in the mid-1980s (these are awaiting renumbering). For brevity, authorship of taxonomic hierarchy above genus level is not cited in the References; these bibliographic sources are listed in the revised (2nd edition) Treatise of Invertebrate Paleontology, Part H: Brachiopoda Volume 3 (Williams et al. 2000).

Phylum Brachiopoda Duméril, 1806
Subphylum Rhynchonelliformea Williams, Carlson, Brunton, Holmer and Popov, 1996
Class Strophomenata Williams, Carlson, Brunton, Holmer and Popov, 1996
Order Strophomenida Öpik, 1934
Superfamily Strophomenoidea King, 1846
Family Strophomenidae King, 1846
Subfamily Furcitellinae Williams, 1965

***Geniculomena* gen. nov.**

Type species (by monotypy): *Geniculomena barnesi* gen. et sp. nov.

Diagnosis

Dorsally geniculate planoconvex to weakly concavoconvex furcitellin with unequally

cuprafodina, *Paromalomena zheni*, *Shlyginia rectangularis*, *Parastrophina* sp. and *Eoanastrophia*? sp.

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parvicostellate ornament lacking rugae; teeth and sockets without crenulations; dorsal myophragm absent; septa associated with dorsal muscle field are less strongly developed than single continuous median ridge.

***Geniculomena barnesi* gen. et sp. nov.**

Fig. 3 A-N

Diagnosis

As for genus.

Etymology

Genus name in reference to geniculate dorsal valve profile and broadly crescent-like shell outline; species name honours David Barnes, photographer in the NSW Department of Primary Industries, in appreciation of the assistance he has provided to me

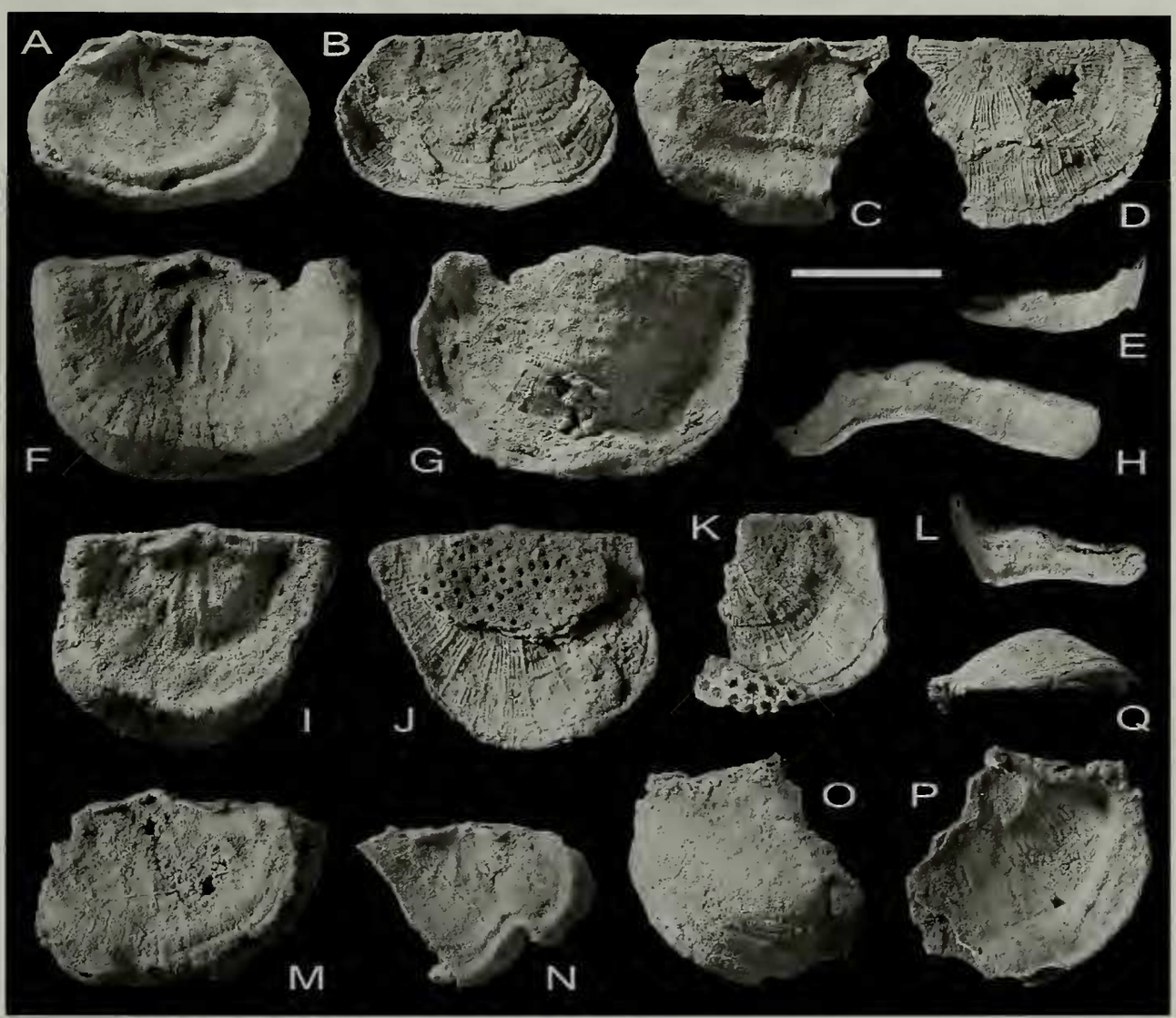

Figure 3. *Geniculomena barnesi* gen. et sp. nov. A – B: interior and exterior of dorsal valve, holotype MMF 44915. C – E: interior, exterior and lateral profile (dorsal side uppermost) of dorsal valve, MMF 44916. F – H: interior, exterior and anterior profile (dorsal side uppermost) of dorsal valve, MMF 44919. I – J: interior and exterior (bearing heliolitid coral) of dorsal valve, MMF 44917. K – L, O – Q: one incomplete individual shell, which disarticulated during acid dissolution of limestone matrix; K – L: exterior and lateral profile (dorsal side uppermost) of dorsal valve, MMF 44918a; O – Q: exterior, interior and lateral profile (ventral side uppermost) of ventral valve, MMF 44918b. M: interior of dorsal valve, MMF 44920. N: interior of dorsal valve, MMF 44921; note distortion on anterolateral margin, probably indicating repaired injury. Scale bar below C represents one cm. A – E, I – L, O – Q from L24, Trilobite Hill Limestone Member of Vandon Limestone, upper Cliefden Caves Limestone Subgroup at Licking Hole Creek near Walli; F – H from L135 (east of Copper Mine Creek, near Cliefden Caves) in Trilobite Hill Limestone Member of Vandon Limestone, upper Cliefden Caves Limestone Subgroup; M – N from L143, upper Billabong Creek Limestone at Billabong Creek road crossing south of Gunningbland.

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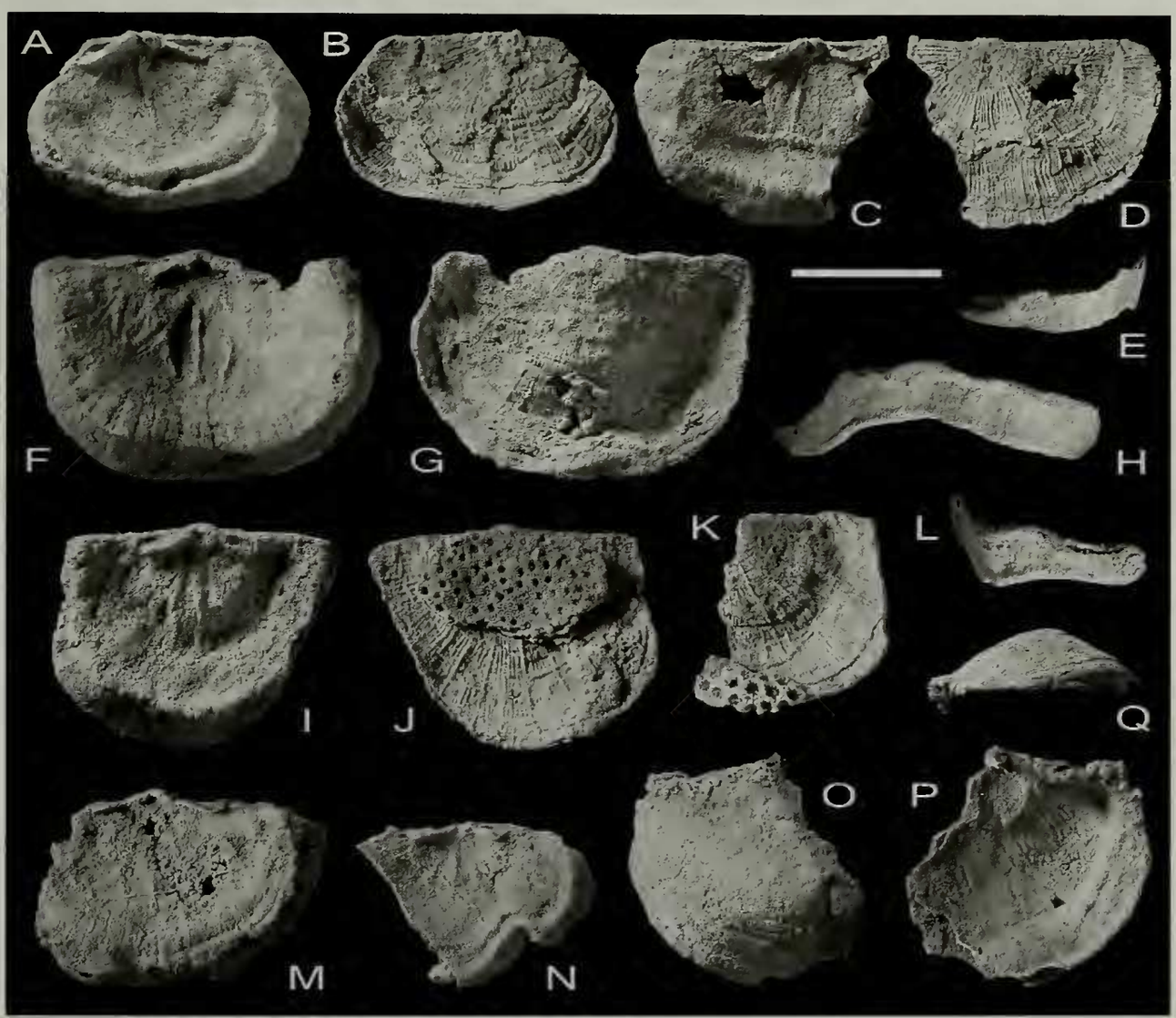

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over the past decade in preparing many illustrations of fossils for publication.

Material

Five dorsal valves, mostly entire, and one partial ventral valve with corresponding partial dorsal valve (disarticulated), all material silicified. Holotype is dorsal valve MMF 44915; paratypes include dorsal valves MMF 44916, MMF 44917, MMF 44919, MMF 44920 and 44921, and ventral valve MMF 44918a and corresponding dorsal valve 44918b.

Localities

Type locality is L24 (Licking Hole Creek area), in Trilobite Hill Limestone Member of Vandon Limestone, upper Cliefden Caves Limestone Subgroup; also found in same stratigraphic unit at L135 (east of Copper Mine Creek, near Cliefden Caves); also occurs at L143 in upper Billabong Creek Limestone, at Billabong Creek road crossing south of Gunningbland [full details of these localities are given by Percival 1991].

Description

Shell planoconvex to very weakly concavoconvex (rarely ventribiconvex, e.g. Fig. 3G), becoming dorsally geniculate when fully grown; transversely subquadrate with maximum width either at, or immediately anterior to, hingeline; lateral and anterior margins broadly curved. Shell of moderate size, ranging in length from 12 to 16 mm, and in width from 23 to 29 mm in largest specimens; length to width ratio 0.55 -0.80. Ornament unequally parvicostellate, with every fourth or fifth rib accentuated; rugae lacking; exterior of the sole ventral valve assigned to this species is almost entirely devoid of ornament, but this may have been eroded prior to fossilization.

Ventral interior (described from an incomplete valve) shows robust oblique teeth supported by low plates for approximately three-quarters length; dental plates extend anteriorly to bound triangular diductor scars flanking (but not enclosing) narrower median pair of adductor scars separated by low median ridge not extending forward of muscle field which occupies three-eighths valve length. Mantle canals prominent, of lemniscate type with anteriorly divergent *vascula media* not enclosing *vascula genitalia*. A distinct but low subperipheral rim defines a dorsally-deflected marginal band approximately one-seventh of valve length extending around entire lateral and anterior valve margin. Details of interarea and delthyrium not known.

Dorsal interior with Type A strophomenoidean cardinalia consisting of twin cardinal process lobes extending just posterior to hingeline and convergent above a hollow, with narrow, widely divergent socket ridges recurved posterolaterally at extremities; sockets short but deep; no crenulations visible on socket ridges. Notothyrial platform poorly developed, lacking myophragm; low median septum extends from immediately in front of cardinal process lobes to terminate at about half valve length, separating moderately conspicuous pair of adductor scars which are bounded by weaker side septa; short transmuscle septa barely visible or lacking. Mantle canals apparently lemniscate, poorly expressed, except for *vascula genitalia* in largest specimen. A variably defined subperipheral ridge is sometimes developed slightly posterior to dorsally-directed geniculation of marginal band.

Dimensions

Holotype MMF 44915: length 12.0 mm, width 19.0 mm; paratypes MMF 44916: length 13.1 mm, estimated width 23 mm; MMF 44917: length 15.5 mm, width of specimen (incomplete) 18.8 mm; MMF 44919: length 16.0 mm, width 23.5 mm; MMF 44920: length 13.5 mm, estimated width 22.5 mm; MMF 44918a (vv): length 15.9 mm, estimated width 29 mm.

Discussion

Geniculomena is assigned to the subfamily Furcitellinae, rather than the Strophomeninae, due to the presence of a moderately well-defined dorsal muscle field in some specimens, although muscle bounding ridges, side septa and transmuscle septa are somewhat variably developed and may be barely discernible in other examples depending on degree of silicification. Dorsally geniculate genera similar to *Geniculomena* are more typical of furcitellins rather than strophomenins. *Dactylogonia* Ulrich and Cooper, 1936 (and its synonym *Cyphomena* Cooper, 1956) appears to closely resemble *Geniculomena* in general morphology, but *Dactylogonia* is readily distinguished by its much stronger development of transmuscle and side septa in the dorsal valve. The new genus lacks the characteristic rugate ornament of *Bellimurina* Cooper, 1956, and differs internally in absence of a forked anterior termination to the dorsal median ridge.

Although *Geniculina* Rõõmusoks, 1993, from the latest Ordovician (Hirnantian) of the Baltic region, is broadly similar to *Geniculomena*, the new genus apparently lacks the prominent posterolateral oblique rugae developed on the ventral valve of *Geniculina*. Nor have crenulations been observed on the teeth and socket ridges of *Geniculomena*, whereas these are

over the past decade in preparing many illustrations of fossils for publication.

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Five dorsal valves, mostly entire, and one partial ventral valve with corresponding partial dorsal valve (disarticulated), all material silicified. Holotype is dorsal valve MMF 44915; paratypes include dorsal valves MMF 44916, MMF 44917, MMF 44919, MMF 44920 and 44921, and ventral valve MMF 44918a and corresponding dorsal valve 44918b.

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characteristic of at least four species of *Geniculina* (e.g., Rõõmusoks 2004, pl. IX fig. 12, pl. XI fig. 6). The median septum in *Geniculomena* is a single ridge that extends from the cardinal process and is rather more prominent than the side septa, unlike the arrangement in *Geniculina* that has strong side septa and a stout myophragm which bifurcates at its anterior extremity.

The multicostellate ornament of *Maakina* Andreeva, 1961 (in Nikiforova and Andreeva 1961), from the early Katian of the Siberian Platform, is quite different from that of *Geniculomena*. Internally, the absence of a dorsal median septum and presence of crenulations on the socket ridges in *Maakina* are additional features clearly distinguishing these two genera.

Distribution

Early Eastonian (Ea2), equivalent to basal Katian; presently monotypic and known only from limestones of the Macquarie Arc in central NSW.

***Murinella* Cooper, 1956**

Type species: *Murinella partita* Cooper, 1956

***Murinella walliensis* (Percival, 1991)**

Fig. 4 A-G

Synonymy

Oepikina? *walliensis* Percival, 1991: p.147, fig. 14.20-28.

Discussion

Two species with *Oepikina*-like morphology have previously been described from the Late Ordovician of central NSW. One form from the Gunningbland Formation was tentatively referred to *Oepikina*? sp. by Percival (1979b), and a new species *Oepikina*? *walliensis* was described by Percival (1991) from the Licking Hole Creek area, occurring in strata equivalent to the basal Belubula Limestone. In their revision of the superfamily Strophomenoidea, Rong and Cocks (1994, p.694) noted that the cardinalia of *O*? *walliensis* was "of the *Strophomena* group", presumably implying that in their view the species was a strophomenin rather than a furcitellin. Zhan *et al.* (2008) observed that these two subfamilies are difficult to separate using the revised Treatise classification (Cocks and Rong 2000). Rong and Cocks (1994, text-fig. 3) also presented a well-illustrated comparison between the dorsal cardinalia of the type species of *Strophomena* and *Murinella*. Although a reclassification of *O*? *walliensis* on the basis of cardinalia alone might therefore be superfluous, the comments by Rong and Cocks (1994) have prompted a reassessment of other possible generic affinities of

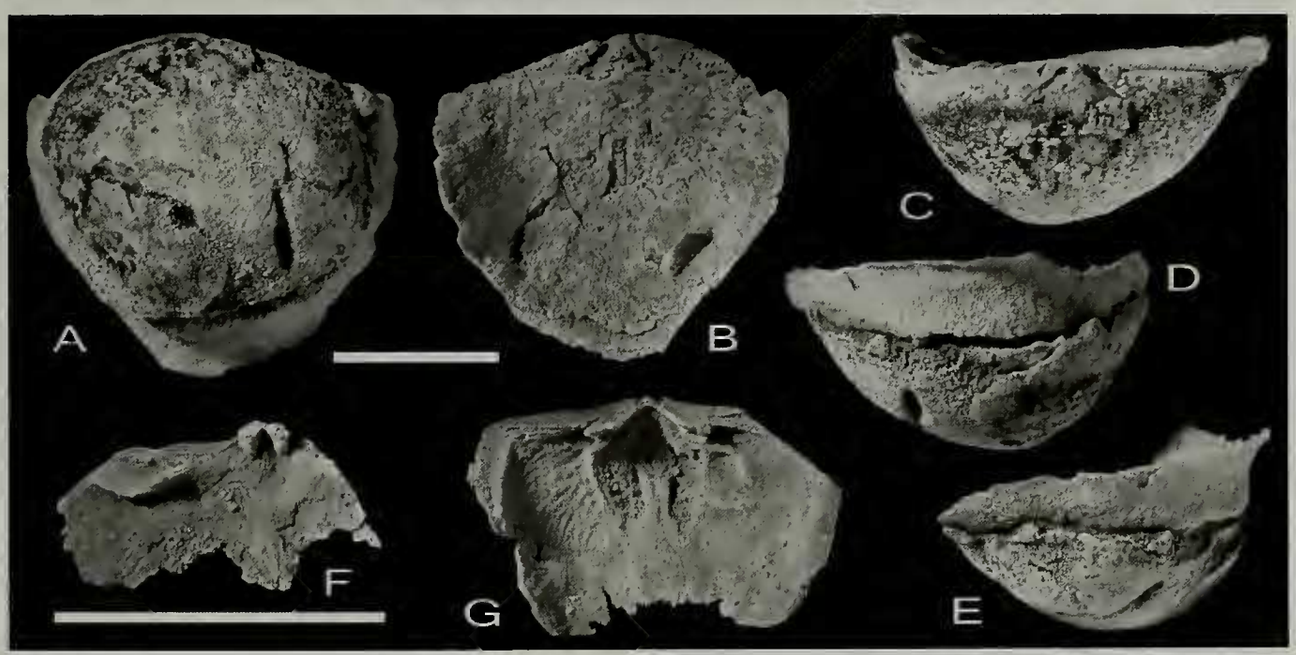

Figure 4. *Murinella walliensis* (Percival, 1991). A – E: Holotype SUP 68516, exterior of conjoined valves, dorsal, ventral, posterior profile, anterior profile and lateral profile respectively. F: fragment of dorsal valve interior showing cardinalia, SUP 68523. G: interior of ventral valve, SUP 68518. Both scale bars represent 1 cm (that beneath F pertains only to this specimen; the shorter scale bar applies to specimens A-E and G). All specimens from basal Belubula Limestone at Licking Hole Creek, near Walli.

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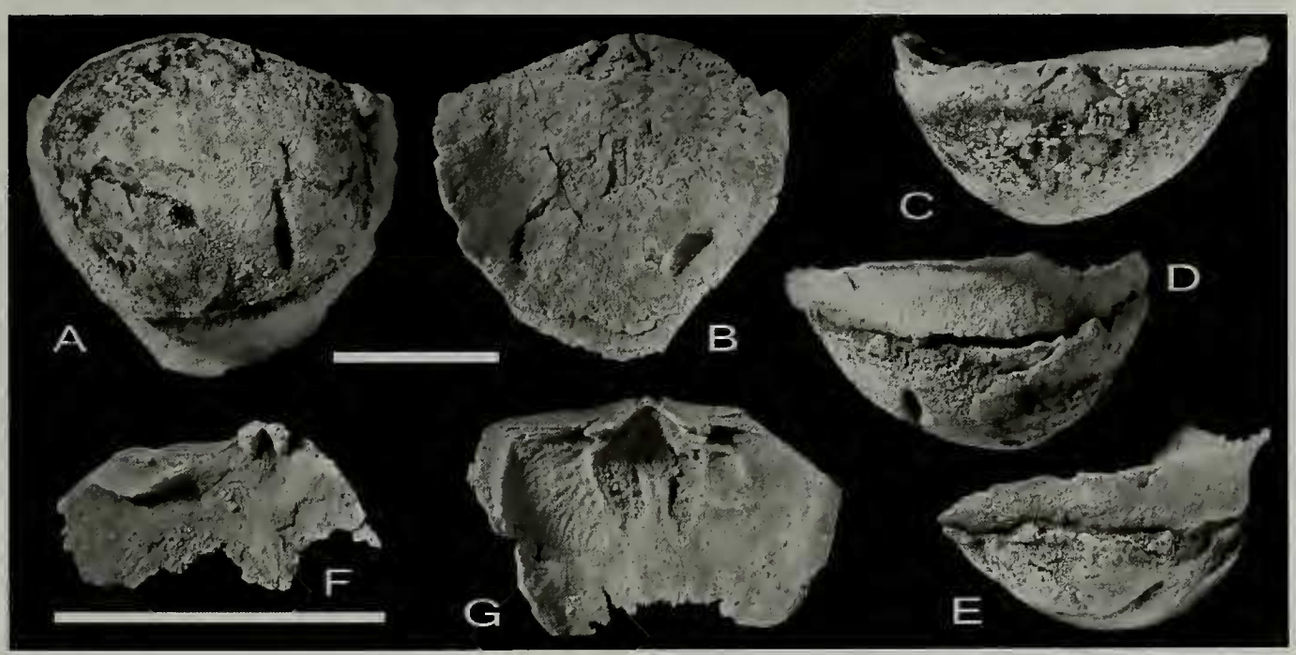

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The holotype of *O? walliensis* is here refigured, together with a paratype fragment showing the cardinalia and a ventral valve interior. Reasons given by Percival (1991) for provisionally assigning this species to *Oepikina* include poorly developed septa in the dorsal valve, and presence of a relatively small ventral muscle field enclosed by low bounding ridges. Both these features are atypical of *Oepikina*, whereas they are characteristic of the similar genus *Murinella* Cooper, 1956. Although a distinguishing feature of the type species of *Murinella*, *M. partita* Cooper, 1956, is the extension of the median septum anterior to the ventral muscle field, not all species show this (e.g. *M. muralis* Cooper, 1956 and *M. semireducta* Cooper, 1956). In retrospect, *O? walliensis* accords best with *Murinella*, and it is here designated *M. walliensis* (Percival, 1991). Other features supporting this reassignment include the relatively large pseudodeltidium and prominent subperipheral rim in the dorsal valve of *M. walliensis*. Furthermore, the cardinalia definitely conform to the *Murinella* model.

A species of *Murinella* has also been described from the lower limestone member of the Benjamin Limestone in Tasmania by Laurie (1991). That species, *M. magna*, is distinguished by its much larger dimensions, and in having a median septum extending forward of the ventral muscle field, compared to *M. walliensis*.

Oepikina? sp from Gunningbland is known only from one specimen (Percival 1979b, fig. 1.12), which clearly shows the presence of Type A cardinalia (*sensu* Rong and Cocks 1994). In all other features this dorsal valve is definitely *Oepikina*-like, with strong side septa, but the absence of a corresponding ventral valve continues to prevent a confident assignment to that genus. The external mould supposedly of a dorsal valve (SUP 62569), mentioned but not figured by Percival (1979b, p.183), is now considered to be a ventral valve of *Testaprica rhodesi* (see below) rather than being related to *Oepikina*.

Family Rafinesquinidae Schuchert, 1893
Subfamily Rafinesquininae Schuchert, 1893

Testaprica gen. nov.

Type species (by monotypy): *Testaprica rhodesi* gen. et sp. nov.

Diagnosis

Convexo-concave to convexo-planar rafinesquinin similar to *Rhipidomena* but with prominent subparallel side septa in dorsal valve; other septa and median ridge subdued or lacking.

Testaprica rhodesi gen. et sp. nov.

Fig. 5 A-H

Diagnosis

As for genus.

Etymology

Genus name derived from testa (Latin): shell, and apricum (Latin): a sunny spot, in reference to the occurrence of this brachiopod adjacent to "Sunnyside" property; species named in honour of Julie and John Rhodes, former owners of "Sunnyside" and "Currajong Park" properties at Gunningbland, who kindly provided access to collect on their land, and who also recognised and donated several important brachiopods and trilobites for scientific description.

Material

Holotype: MMF 36806a and b, dorsal valve internal mould and external mould of corresponding ventral valve. Paratypes: MMF 36798a and b, dorsal valve internal and external moulds; MMF 36801 and MMF 36805, both external moulds of dorsal valves; MMF 36813, dorsal valve internal mould; SUP 62569 ventral valve external mould.

Localities

All specimens from upper Gunningbland Formation on "Currajong Park", Gunningbland at locality L51 [see Percival 1979a for full details] with exception of MMF 36813, collected from locality L48 situated in immediately underlying beds in the same formation on this property.

Description

Large convexo-concave to convexo-planar shells up to 40 mm wide and 30 mm long, with maximum width attained at or immediately anterior to hingeline; anterolateral and anterior margins very broadly rounded. Length to width ratio varies between two-thirds and almost three-quarters. Ornament finely and evenly multicostellate, lacking rugae; costellae slightly curved on lateral flanks; occasional concentric growth discontinuities may be present, but concentric filae lacking.

Ventral valve weakly concave, becoming almost planar anteriorly; interarea low, catacline to weakly apsacline, with small pseudodeltidium. Details of interior unknown.

Dorsal valve strongly convex; interarea very low with delicate chilidial plates (poorly preserved on

this species.

The holotype of *O? walliensis* is here refigured, together with a paratype fragment showing the cardinalia and a ventral valve interior. Reasons given by Percival (1991) for provisionally assigning this species to *Oepikina* include poorly developed septa in the dorsal valve, and presence of a relatively small ventral muscle field enclosed by low bounding ridges. Both these features are atypical of *Oepikina*, whereas they are characteristic of the similar genus *Murinella* Cooper, 1956. Although a distinguishing feature of the type species of *Murinella*, *M. partita* Cooper, 1956, is the extension of the median septum anterior to the ventral muscle field, not all species show this (e.g. *M. muralis* Cooper, 1956 and *M. semireducta* Cooper, 1956). In retrospect, *O? walliensis* accords best with *Murinella*, and it is here designated *M. walliensis* (Percival, 1991). Other features supporting this reassignment include the relatively large pseudodeltidium and prominent subperipheral rim in the dorsal valve of *M. walliensis*. Furthermore, the cardinalia definitely conform to the *Murinella* model.

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Type species (by monotypy): *Testaprica rhodesi* gen. et sp. nov.

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Testaprica rhodesi gen. et sp. nov.

Fig. 5 A-H

Diagnosis

As for genus.

Etymology

Genus name derived from testa (Latin): shell, and apricum (Latin): a sunny spot, in reference to the occurrence of this brachiopod adjacent to "Sunnyside" property; species named in honour of Julie and John Rhodes, former owners of "Sunnyside" and "Currajong Park" properties at Gunningbland, who kindly provided access to collect on their land, and who also recognised and donated several important brachiopods and trilobites for scientific description.

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Holotype: MMF 36806a and b, dorsal valve internal mould and external mould of corresponding ventral valve. Paratypes: MMF 36798a and b, dorsal valve internal and external moulds; MMF 36801 and MMF 36805, both external moulds of dorsal valves; MMF 36813, dorsal valve internal mould; SUP 62569 ventral valve external mould.

Localities

All specimens from upper Gunningbland Formation on "Currajong Park", Gunningbland at locality L51 [see Percival 1979a for full details] with exception of MMF 36813, collected from locality L48 situated in immediately underlying beds in the same formation on this property.

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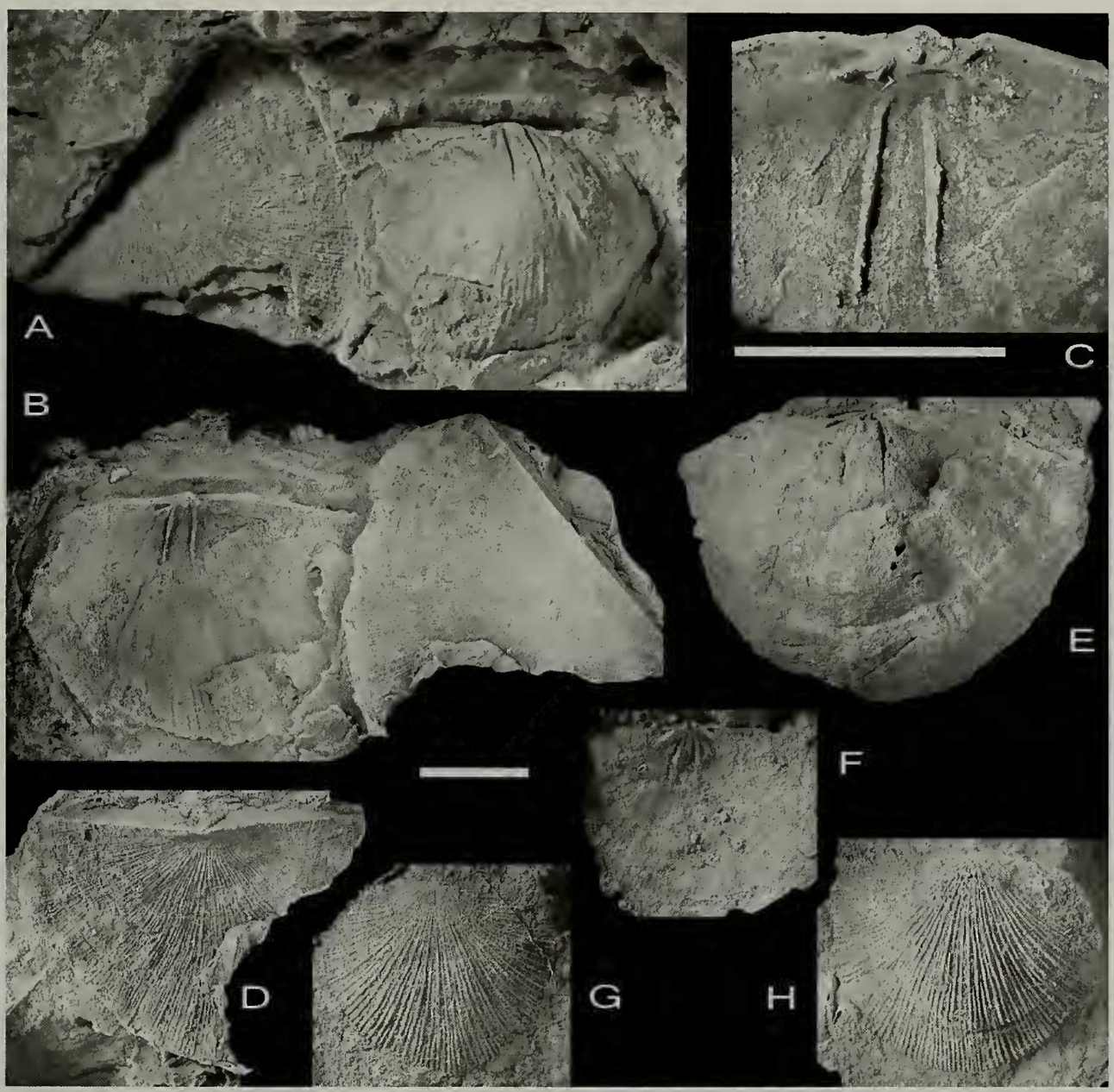
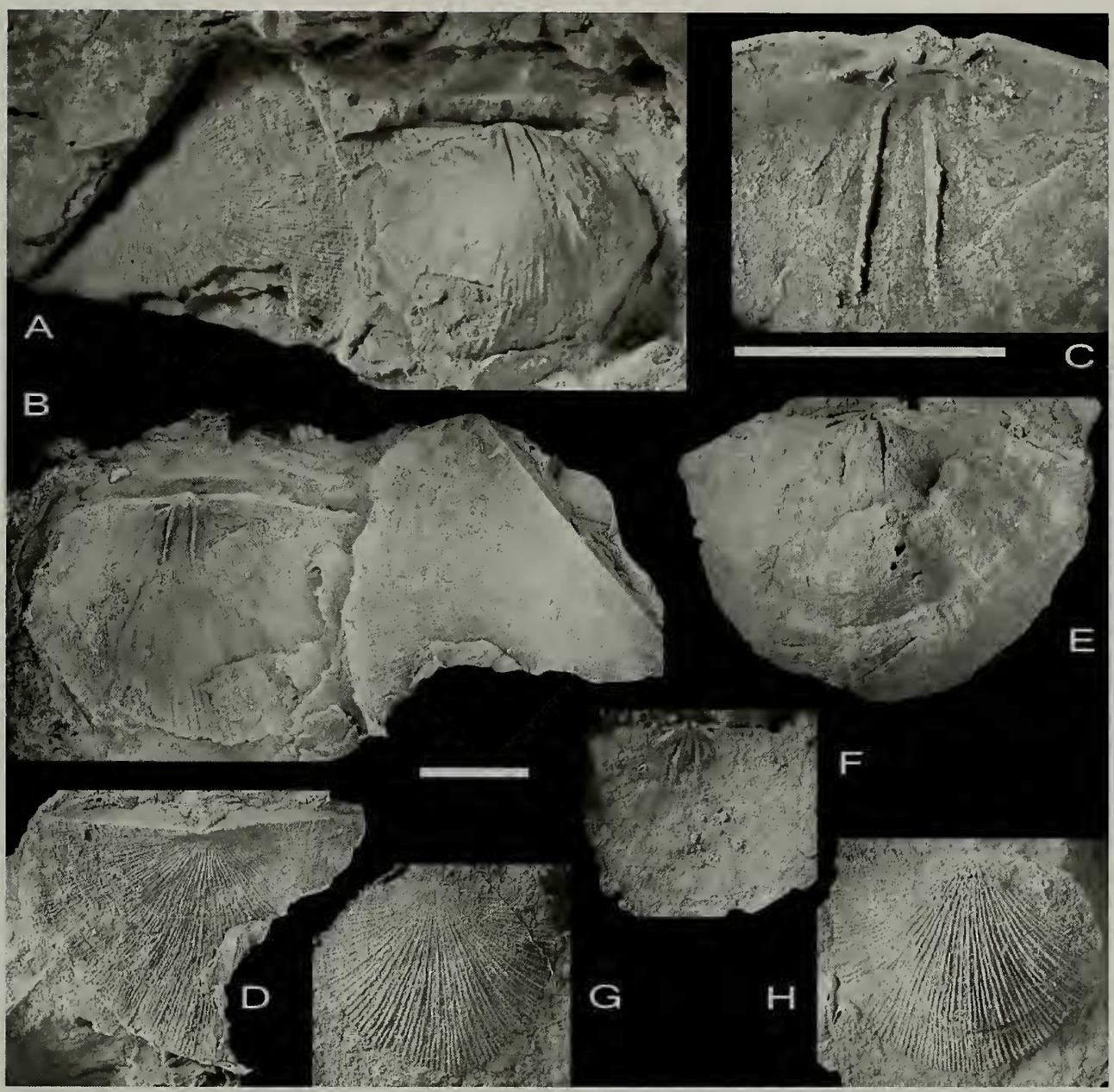


Figure 5. ***Testaprica rhodesi*** **gen. et sp. nov. All specimens from upper beds of the Gunningbland Formation on "Currajong Park", Gunningbland. A – D: Holotype, MMF 36806a and b; A: exterior mould of ventral valve (on left, 36806a) and interior mould of corresponding dorsal valve (on right, 36806b); B: latex replica taken from this specimen; C: enlargement of posterior region of latex replica of dorsal valve; D: latex replica of exterior of ventral valve, tilted to better show ornament and interarea. E: interior mould of dorsal valve, MMF 36798a. F: latex replica of dorsal valve, MMF 36813. G: latex replica of exterior of dorsal valve, MMF 36805. H: latex replica of exterior of dorsal valve, MMF 36801. Both scale bars represent 1 cm (that below C pertains only to this enlargement).**

available specimens). Cardinalia consisting of small cardinal process with pair of discrete peg-like lobes above low notothyrial platform, with very short, straight socket ridges extending obliquely; median ridge either very short or not developed; prominent subparallel pair of side septa, low and thin, extend to between one quarter and one third valve length; transmuscle septa barely visible; muscle bounding ridges not present and muscle field not impressed. Mantle canals not discernible.

Dimensions

MMF 36806a, b (holotype): DV internal mould and VV external mould L= 26.3 mm, hinge W= 39.3 mm;



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available specimens). Cardinalia consisting of small cardinal process with pair of discrete peg-like lobes above low notothyrial platform, with very short, straight socket ridges extending obliquely; median ridge either very short or not developed; prominent subparallel pair of side septa, low and thin, extend to between one quarter and one third valve length; transmuscle septa barely visible; muscle bounding ridges not present and muscle field not impressed. Mantle canals not discernible.

Dimensions

MMF 36806a, b (holotype): DV internal mould and VV external mould L= 26.3 mm, hinge W= 39.3 mm;

MMF 36798a, b: DV internal and external moulds L= 28.4 mm, W= 39.3 mm;

MMF 36801: DV external mould L= 22.4 mm, spec W= 25.3 mm, W= 29.6 mm;

MMF 36805: DV external mould L= 16.0 mm, W= 22.0 mm;

MMF 36813: DV internal mould L= 17.6 mm;

SUP 62569: VV external mould L= 13.5 mm, W= 17.5 mm.

Discussion

This monotypic genus has cardinalia of Type B (*sensu* Rong and Cocks 1994), with small discrete cardinal process lobes that are not continuous with a median ridge, and which are also definitely disjunct from the socket ridges (the latter being straight and oblique, rather than recurved laterally towards the hingeline as in strophomenids). Clearly then, its affinities lie with the rafinesquinids. The only previously described rafinesquinin brachiopod with a convexo-concave valve profile is *Rhipidomena*, which is of generally comparable size. However, dorsal valves of the 5-6 species of this genus known from North America (Cooper 1956), are never quite as convex as is *Testaprica*, and the latter is not resupinate as is commonly the case with *Rhipidomena*. In possessing prominent side septa *T. rhodesi* differs from all North American *Rhipidomena* species, and is further distinguished by its relatively poorly developed median ridge and transmuscle septa (although there is some variation in the strength of these features). These distinctions in total appear to be of generic significance, so that despite the absence of ventral interiors the establishment of a new genus is warranted.

Equally prominent side septa are also characteristic of *Lateriseptomena* Zhan, Jin, Rong, Chen and Yu, 2008, known from two species of late Katian age from Zhejiang Province, south-east China. However, *Lateriseptomena* has Type C (glyptomenid) cardinalia, and furthermore has a planoconvex to biconvex profile, so is apparently not closely related to *Testaprica*. The concavo-convex profile of *Dirafinesquina* Cocks and Zhan, 1998, from Upper Naungkangyi Group equivalent strata (probable Katian age) in the Southern Shan States of Burma, readily distinguishes this genus from *Testaprica*; the few known dorsal interiors of *Dirafinesquina* also lack the characteristic side septa of the new genus.

Distribution

Presently known only from the Gunningbland Formation (upper part) in vicinity of Gunningbland village, between Parkes and Bogan Gate, central west NSW; late Eastonian (Ea3-4) i.e. Katian.

Family Glyptomenidae Williams, 1965
Subfamily Glyptomeninae Williams, 1965

***Resupinsculpta* gen. nov.**

Type species (by monotypy): *Resupinsculpta cuprafodina* gen. et sp. nov.

Diagnosis

Resupinate glyptomenin displaying weak rugation on exterior of both valves; teeth and socket ridges occasionally crenulate.

***Resupinsculpta cuprafodina* gen. et sp. nov.**

Fig. 6 A-P

Diagnosis

As for genus.

Etymology

Genus name in reference to resupinate profile and finely engraved appearance of ornament (resupinus: L bent back; insculptus: L engraved); species name in reference to Copper Mine Creek, the type locality (cuprum: L copper; fodina: L mine or pit).

Material

Holotype MMF 44923 (conjoined valves); paratypes include MMF 44924 (ventral valve), MMF 44925 (dorsal valve), MMF 44926 (ventral valve), MMF 44927 (dorsal valve), MMF 44928 (ventral valve), and MMF 44929 (conjoined valves). All specimens are silicified.

Localities

Type locality L135 (east of Copper Mine Creek, near Cliefden Caves), in Trilobite Hill Limestone Member of Vandon Limestone, upper Cliefden Caves Limestone Subgroup; also found at L138 ("Quondong", Bowan Park, east of Cudal) in Quondong Limestone, Bowan Park Subgroup; and at L144 in upper Billabong Creek Limestone beside the road crossing Billabong Creek, south of Gunningbland [full details of these localities are given by Percival 1991].

Description

Shell relatively small, length up to 12 mm and width to approximately 18 mm; outline subquadrate initially, becoming transverse and slightly auriculate when fully grown with maximum width at hinge line; length two-thirds width in these largest specimens.

MMF 36798a, b: DV internal and external moulds L= 28.4 mm, W= 39.3 mm;

MMF 36801: DV external mould L= 22.4 mm, spec W= 25.3 mm, W= 29.6 mm;

MMF 36805: DV external mould L= 16.0 mm, W= 22.0 mm;

MMF 36813: DV internal mould L= 17.6 mm;

SUP 62569: VV external mould L= 13.5 mm, W= 17.5 mm.

Discussion

This monotypic genus has cardinalia of Type B (*sensu* Rong and Cocks 1994), with small discrete cardinal process lobes that are not continuous with a median ridge, and which are also definitely disjunct from the socket ridges (the latter being straight and oblique, rather than recurved laterally towards the hingeline as in strophomenids). Clearly then, its affinities lie with the rafinesquinids. The only previously described rafinesquinin brachiopod with a convexo-concave valve profile is *Rhipidomena*, which is of generally comparable size. However, dorsal valves of the 5-6 species of this genus known from North America (Cooper 1956), are never quite as convex as is *Testaprica*, and the latter is not resupinate as is commonly the case with *Rhipidomena*. In possessing prominent side septa *T. rhodesi* differs from all North American *Rhipidomena* species, and is further distinguished by its relatively poorly developed median ridge and transmuscle septa (although there is some variation in the strength of these features). These distinctions in total appear to be of generic significance, so that despite the absence of ventral interiors the establishment of a new genus is warranted.

Equally prominent side septa are also characteristic of *Lateriseptomena* Zhan, Jin, Rong, Chen and Yu, 2008, known from two species of late Katian age from Zhejiang Province, south-east China. However, *Lateriseptomena* has Type C (glyptomenid) cardinalia, and furthermore has a planoconvex to biconvex profile, so is apparently not closely related to *Testaprica*. The concavo-convex profile of *Dirafinesquina* Cocks and Zhan, 1998, from Upper Naungkangyi Group equivalent strata (probable Katian age) in the Southern Shan States of Burma, readily distinguishes this genus from *Testaprica*; the few known dorsal interiors of *Dirafinesquina* also lack the characteristic side septa of the new genus.

Distribution

Presently known only from the Gunningbland Formation (upper part) in vicinity of Gunningbland village, between Parkes and Bogan Gate, central west NSW; late Eastonian (Ea3-4) i.e. Katian.

Family Glyptomenidae Williams, 1965
Subfamily Glyptomeninae Williams, 1965

***Resupinsculpta* gen. nov.**

Type species (by monotypy): *Resupinsculpta cuprafodina* gen. et sp. nov.

Diagnosis

Resupinate glyptomenin displaying weak rugation on exterior of both valves; teeth and socket ridges occasionally crenulate.

***Resupinsculpta cuprafodina* gen. et sp. nov.**

Fig. 6 A-P

Diagnosis

As for genus.

Etymology

Genus name in reference to resupinate profile and finely engraved appearance of ornament (resupinus: L bent back; insculptus: L engraved); species name in reference to Copper Mine Creek, the type locality (cuprum: L copper; fodina: L mine or pit).

Material

Holotype MMF 44923 (conjoined valves); paratypes include MMF 44924 (ventral valve), MMF 44925 (dorsal valve), MMF 44926 (ventral valve), MMF 44927 (dorsal valve), MMF 44928 (ventral valve), and MMF 44929 (conjoined valves). All specimens are silicified.

Localities

Type locality L135 (east of Copper Mine Creek, near Cliefden Caves), in Trilobite Hill Limestone Member of Vandon Limestone, upper Cliefden Caves Limestone Subgroup; also found at L138 ("Quondong", Bowan Park, east of Cudal) in Quondong Limestone, Bowan Park Subgroup; and at L144 in upper Billabong Creek Limestone beside the road crossing Billabong Creek, south of Gunningbland [full details of these localities are given by Percival 1991].

Description

Shell relatively small, length up to 12 mm and width to approximately 18 mm; outline subquadrate initially, becoming transverse and slightly auriculate when fully grown with maximum width at hinge line; length two-thirds width in these largest specimens.

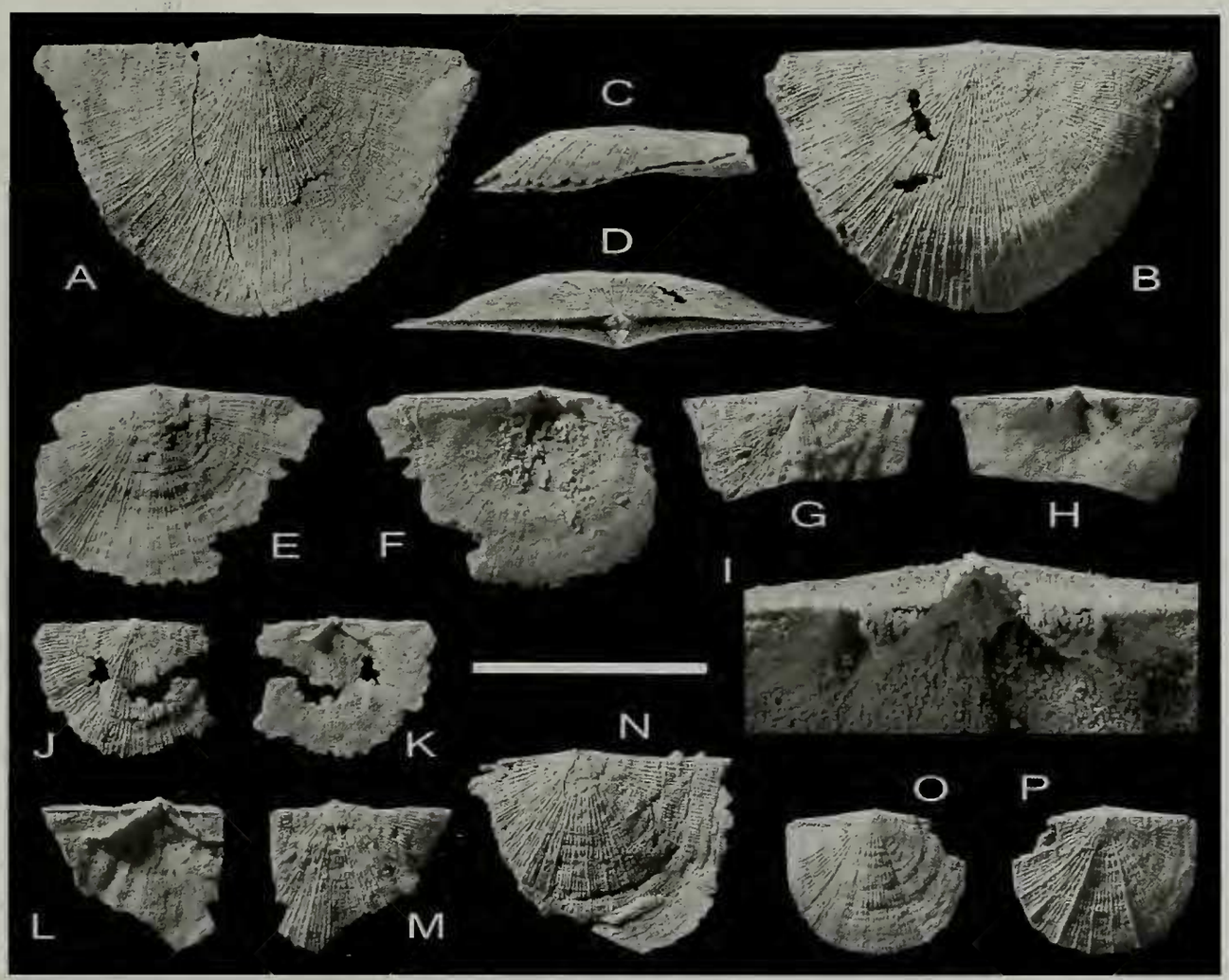
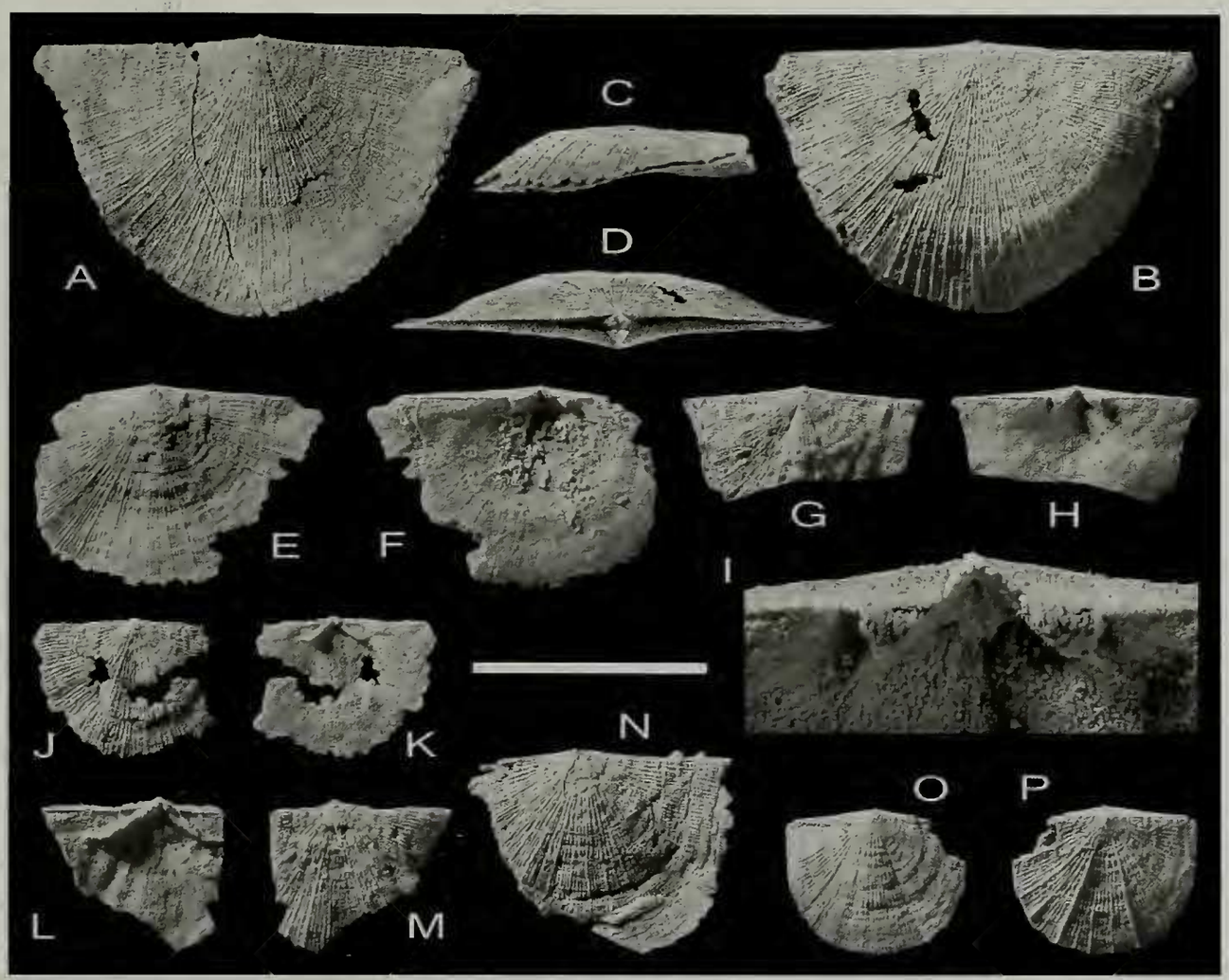


Figure 6. ***Resupinsculpta cuprafodina*** **gen. et sp. nov. A – D: Holotype conjoined valves, MMF 44923; A: exterior of ventral valve; B: exterior of dorsal valve; C: lateral profile (dorsal valve uppermost); D: posterior profile (dorsal valve uppermost). E – F: exterior and interior of ventral valve, MMF 44924. G – I: exterior and interior of ventral valve, and enlargement of delthyrium to show crenulated teeth, MMF 44926. J – K: exterior and interior of dorsal valve, MMF 44925. L – M: interior and exterior of dorsal valve, MMF 44927. N: exterior of ventral valve, MMF 44928. O – P: conjoined valves, ventral and dorsal exteriors respectively, MMF 44929. Scale bar represents 1 cm for whole figure (except I, which is a five-times enlargement of H). A – F, J – K from L135 (east of Copper Mine Creek, near Cliefden Caves): in Trilobite Hill Limestone Member of Vandon Limestone, upper Cliefden Caves Limestone Subgroup; G – I, N – P from L138 ("Quondong", Bowan Park, east of Cudal) Quondong Limestone, Bowan Park Subgroup.**

Ventral valve with sharply pointed beak; profile initially weakly convex, becoming resupinate in largest specimens; dorsal valve planar posteriorly, gently to moderately convex anteriorly in adults; whole shell very compressed dorsoventrally. Ornament unequally parvicostellate, commonly with 3-4 finer costellae between accentuated ribs, with indistinct rugae developed posteriorly.

Ventral interarea low, apsacline, with wide delthyrium covered apically by pseudodeltidium. Delicate teeth, crenulated in one specimen (Fig. 6I), supported by thin subparallel dental plates that terminate immediately in front of teeth. Muscle field indistinct, apparently very short, not enclosed by ridges. A weak subperipheral rim is present in one specimen. Mantle canals not visible.

Dorsal interarea very low, orthocline to weakly anacline; notothyrium entirely occupied by cardinal process lobes; chilidial plates either lacking or extremely weakly developed. Cardinalia consist of small paired cardinal process lobes fused to long, straight, widely divergent socket ridges (which are



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Dorsal interarea very low, orthocline to weakly anacline; notothyrium entirely occupied by cardinal process lobes; chilidial plates either lacking or extremely weakly developed. Cardinalia consist of small paired cardinal process lobes fused to long, straight, widely divergent socket ridges (which are

finely crenulated in at least one specimen, Fig. 6L) with slightly curved terminations; cardinal process lobes extend very slightly posteriorly of hingeline and anteriorly overhang a concavity in place of notothyrial platform; median ridge short, very low; side and transmuscle septa absent. Muscle field and mantle canals not visible.

Dimensions

Nearly all specimens are incomplete; a juvenile conjoined shell MMF 44929 is 6.2 mm long and 7.7 mm wide; the largest shell (holotype, MMF 44923) is 11.6 mm long and 18.5 mm wide.

Discussion

The new species presents a conundrum as regards its generic affinities. It has Type C (glyptomenin) cardinalia, and conforms in almost all respects with the characteristics of *Glyptomena*, except for the resupinate profile of larger shells. Smaller shells are planoconvex and thus more similar to the typical concavoconvex profile of *Glyptomena*. As shell profile is often used to distinguish genera in strophomenides, it seems reasonable to establish a new genus within the glyptomenines based on the resupinate character. Furthermore, crenulated teeth and socket ridges as seen in *Resupinsculpta cuprafodina* are apparently rare in glyptomenines; Rong and Cocks (1994) only mentioned their occurrence in *Mjoesina*, which was doubtfully assigned to the family (Cocks and Rong 2000), but is now regarded more likely to be a rafinesquinid (Cocks 2005). The indistinct rugae present in the posterior region of the exterior of both valves of *R. cuprafodina* are lacking in species of *Glyptomena*, but the distinctively dorsally geniculate *Glyptomenoides* Popov and Cocks, 2006 (which is otherwise generally similar to *Glyptomena*) also displays irregular rugae. Most comparable of other strophomenids is possibly *Longvillia* Bancroft, 1933, which also is resupinate; however, *Longvillia* has Type A cardinalia and is therefore not closely related to the new genus.

Distribution

Only known from limestones of early Eastonian (Ea2) age, equivalent to the earliest Katian Stage, in the Macquarie Arc, central NSW.

***Paromalomena* Rong, 1984**

Type species: *Platymena polonica* Temple, 1965

***Paromalomena zheni* sp. nov.**

Fig. 7 A-V

Diagnosis

A species of *Paromalomena* distinguished by its prominent pseudodeltidium with a minute foramen at the apex, and lacking conspicuous external rugae.

Etymology

This species is named in honour of my colleague Dr Yong-Yi Zhen, in recognition of his extensive palaeontological studies in the Ordovician of both Australia and China.

Material

Holotype is MMF 44932 (ventral valve); paratypes include MMF 44930 (dorsal valve), MMF 44931 (ventral valve), MMF 44933 (ventral valve), MMF 44934 (conjoined valves), MMF 44935 (dorsal valve), MMF 44936 (ventral valve), MMF 44937 (conjoined valves), MMF 44938 (dorsal valve), MMF 44939 (dorsal valve), MMF 44940 (dorsal valve), MMF 44941 (dorsal valve), MMF 44942 (dorsal valve), MMF 44943 (ventral valve), MMF 44944 (ventral valve), MMF 44945 (ventral valve), and MMF 44946 (conjoined valves). All specimens are silicified.

Localities

Type locality is L138 ("Quondong", Bowan Park, east of Cudal) in Quondong Limestone, Bowan Park Subgroup; also occurs at L24 (Licking Hole Creek area, Walli) in Trilobite Hill Limestone Member of Vandon Limestone, upper Cliefden Caves Limestone Subgroup; and at localities L143 and L144 in upper Billabong Creek Limestone, in vicinity of Billabong Creek road crossing, south of Gunningbland [full details of these localities are given by Percival 1991].

Description

Shells generally small and thin, not exceeding 7.5 mm in length and 9.2 mm in width, with subquadrate to subrectangular outline; hingeline straight and wide, in all but one specimen just slightly narrower than maximum valve width which is approximately coincident with midlength, anterior margin broadly rounded; length:width ratio ranges from 0.65 to 0.88, with average of 0.77 for 18 specimens. Profile generally planoconvex, to weakly concavoconvex with tendency to geniculation dorsally in largest specimens; a subtle sulcus may develop in anteromedian sector of dorsal valve, with corresponding weak fold in ventral valve. Ornament finely and equally parvicostellate, lacking rugae; occasional concentric growth discontinuities may be present. Ventral interarea apsacline, with relatively wide delthyrium at least half

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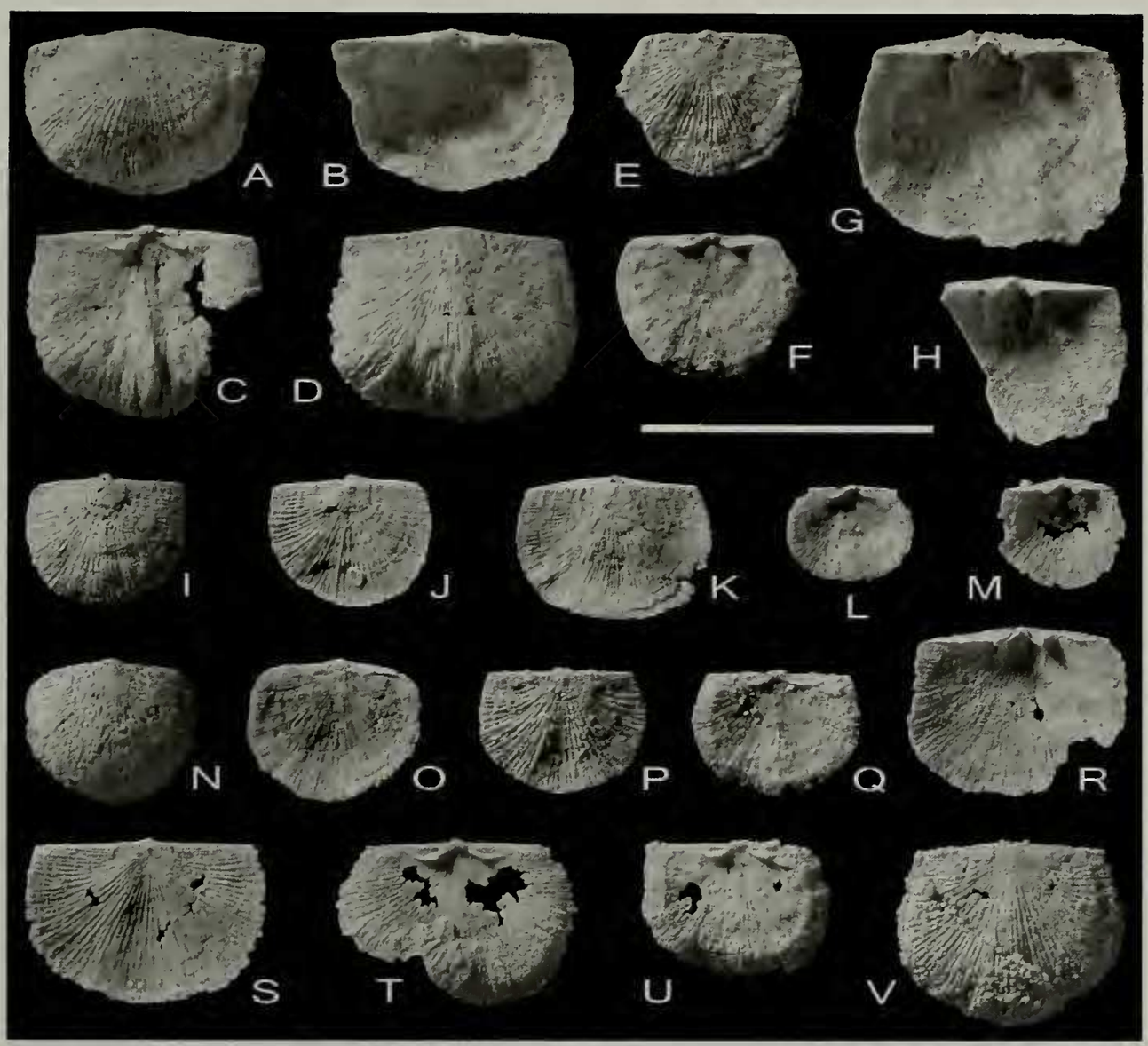
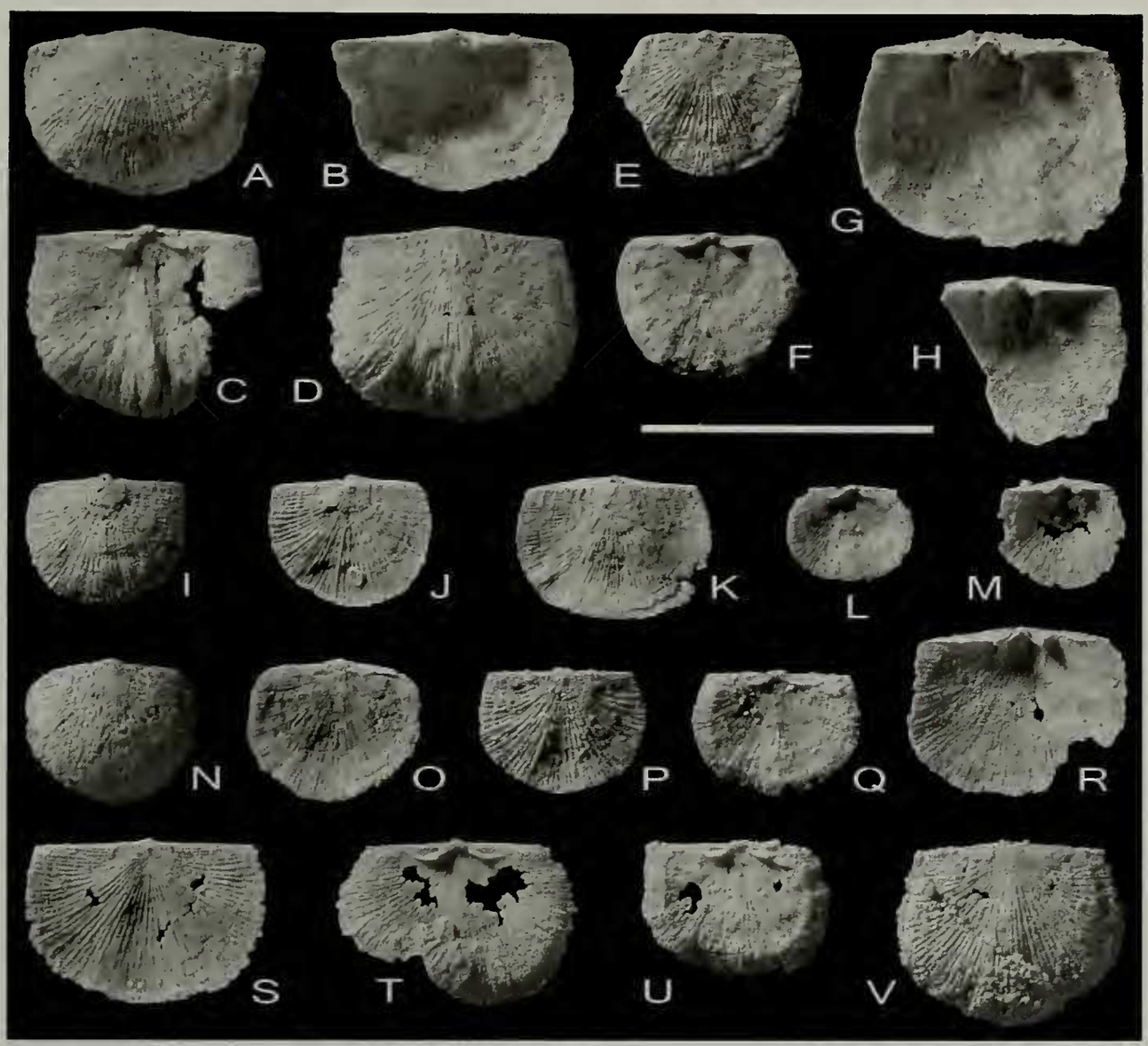


Figure 7. ***Paromalomena zheni*** **sp. nov. A – B: exterior and interior of ventral valve, MMF 44931. C: interior of dorsal valve, MMF 44935. D: exterior of ventral valve, MMF 44936. E – F: exterior and interior of dorsal valve, MMF 44930. G: interior of ventral valve, holotype MMF 44932. H: interior of ventral valve, MMF 44933. I – J: conjoined valves, ventral and dorsal exteriors respectively, MMF 44934. K: dorsal exterior of conjoined valves, MMF 44937. L: interior of juvenile dorsal valve, MMF 44938. M: interior of juvenile ventral valve, MMF 44944. N – O: conjoined valves, ventral and dorsal exteriors respectively, MMF 44946. P – Q: exterior and interior of dorsal valve, MMF 44939. R: interior of ventral valve, MMF 44945. S: exterior of dorsal valve, MMF 44940. T: interior of dorsal valve, MMF 44941. U: interior of dorsal valve, MMF 44942. V: exterior of ventral valve, MMF 44943. Scale bar represents 1 cm. A – L from L138 ("Quondong", Bowan Park, east of Cudal) Quondong Limestone, Bowan Park Subgroup; M, Q – V from L143, upper Billabong Creek Limestone at Billabong Creek road crossing south of Gunningbland; N – O from L24, Trilobite Hill Limestone Member of Vandon Limestone, upper Cliefden Caves Limestone Subgroup at Licking Hole Creek near Walli.**

to three-quarters covered by prominent high convex pseudodeltidium; a minute pedicle foramen is present at apex of pseudodeltidium. Dorsal interarea barely evident, considerably lower than that of ventral valve; chilidial plates (if present) extremely delicate.

Ventral interior: Pedicle foramen about pinhole size, encased in callus at extreme posterior of delthyrial cavity. Small teeth supported by receding dental plates, below which extend anteriorly divergent, subparallel or slightly convergent lateral



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muscle bounding ridges that rapidly decline in height and do not enclose muscle field anteriorly; diductors surround adductors that are embedded in shallow subcircular pit on low median ridge. Muscle field occupies approximately one-third valve length and less than one-quarter width. Mantle canals not observed.

Dorsal interior: Cardinalia of glyptomenin type (Type C), with very delicate cardinal process lobes joined to fine, short socket ridges that diverge and curve to extend subparallel to hingeline; notothyrial platform absent; low, broad median ridge is barely developed in some larger specimens, otherwise lacking; side and transmuscle septa never developed; muscle scars not clearly defined. Mantle canals not discernible, due to thinness of shell material that reflects external costellae.

Dimensions

Valve length ranges from 3.2 mm to 7.5 mm, and valve width ranges from 4.3 mm to 9.2 mm (measurements from 18 individuals; no significant difference between ventral and dorsal valves). Holotype (ventral valve MMF 44932) is 7.5 mm long and 9.2 mm wide; majority of specimens cluster in the range of 5.0-6.5 mm long, and 5.5-8.5 mm wide.

Discussion

This new species shares many morphological characteristics with the cosmopolitan Late Ordovician (late Katian – Hirnantian) genus *Paromalomena* including shell profile and ornament, development of fold and sulcus anteriorly, and in most internal details. It differs from described species mainly in having a conspicuous pseudodeltidium, and in lacking a large chilidium and external rugae. *Paromalomena* typically occurs in deepwater settings (BA 4-6) in distinctive faunal associations such as the *Foliomena* fauna (e.g. Neuman 1994) and the younger *Hirnantia* fauna (e.g. Temple 1965). Like these species, *P. zheni* is quite thin-shelled, but unlike them it occurs in considerably shallower environments (BA 3) and is somewhat older (earliest Katian).

Unlike species of *Glyptomena*, the new species has a furcitellin-like ornament (i.e. equally parvicostellate), and is generally planoconvex rather than concavo-convex, except in largest specimens. *P. zheni* is readily distinguished from *Resupinsculpta cuprafodina*, the other glyptomenin with which it is associated in the same strata in central NSW, by the latter's resupinate profile, unequally parvicostellate ornament and presence of rugae.

Glyptomenoides species differ in having an unequally parvicostellate ornament with rugae developed, and furthermore are quite distinct internally from *P. zheni* which lacks a stout myophragm and transmuscle septa.

Distribution

Limestones of early Eastonian (Ea2) age, equivalent to the earliest Katian Stage, in the Macquarie Arc, central NSW.

Platymena Cooper, 1956

Type species: *Platymena plana* Cooper, 1956

Platymena? sp.

Fig. 8 A-D

Material

MMF 36804, external mould of ventral valve; MMF 36810, internal mould of dorsal valve; MMF 44968, internal mould of dorsal valve (not figured).

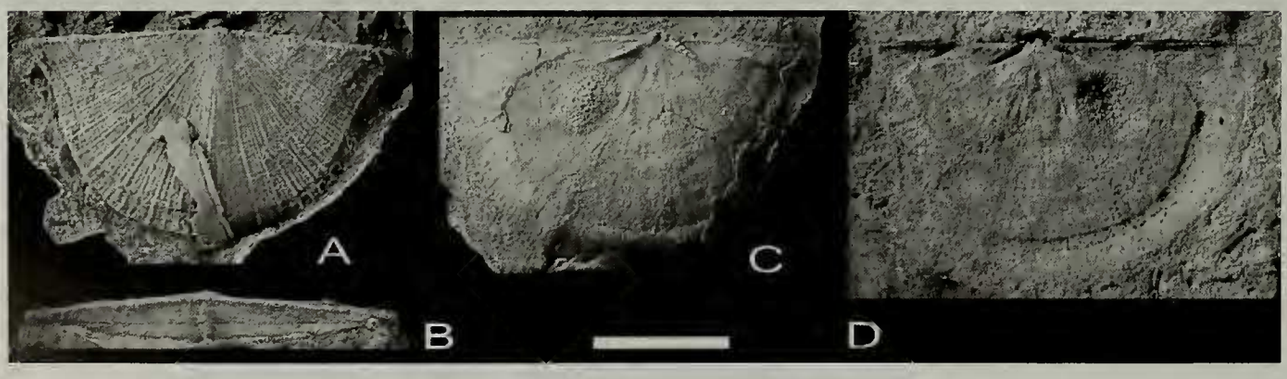

Figure 8. *Platymena*? sp. A – B: latex replica of ventral valve exterior and interarea of conjoined valves, MMF 36804. C – D: latex replica and corresponding internal mould of dorsal valve, MMF 36810. All specimens from upper beds of the Gunningbland Formation on "Currajong Park", Gunningbland. Scale bar represents 1 cm.

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Material

MMF 36804, external mould of ventral valve; MMF 36810, internal mould of dorsal valve; MMF 44968, internal mould of dorsal valve (not figured).

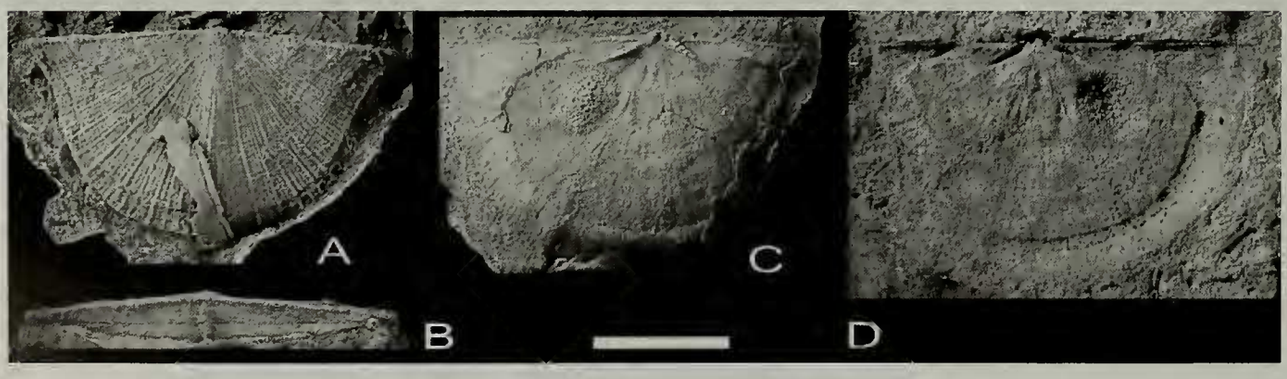

Figure 8. *Platymena*? sp. A – B: latex replica of ventral valve exterior and interarea of conjoined valves, MMF 36804. C – D: latex replica and corresponding internal mould of dorsal valve, MMF 36810. All specimens from upper beds of the Gunningbland Formation on "Currajong Park", Gunningbland. Scale bar represents 1 cm.

Locality

All three known specimens from sandstones in upper Gunningbland Formation on "Currajong Park", Gunningbland at locality L51 [see Percival 1979a for full details].

Description

Transverse auriculate shell with maximum width at hingeline; lateral and anterior margins broadly rounded; profile apparently weakly concavo-convex, with median ventral fold; periphery of both valves dorsally geniculated. Length:width ratio 0.53 (ventral valve), 0.56 (dorsal valve). Ornament unequally parvicostellate, with 2-3 finer costellae separating relatively strongly accentuated costellae; very fine crowded concentric filae are just visible interstitially between costellae; three faint oblique rugae developed on posterolateral flanks.

Ventral valve with low apsacline interarea, and narrow pseudodeltidium extending entire height of interarea. Interior details of ventral valve unknown.

Dorsal valve interarea very low, orthocline to weakly anacline, with small, apparently complete chilidium. Delicate cardinal process lobes are continuous laterally with fine, broadly divergent socket ridges; notothyrial platform beneath cardinal process is barely thickened above valve floor, extending anteriorly as a short, low median ridge; transmuscle septa very poorly developed. Musculature and mantle canals not deeply impressed; muscle field extends no more than one-third valve length. Broadly rounded subperipheral rim slightly raised above dorsal valve floor, geniculate dorsally in anterior portion; width of subperipheral rim greatest in posterolateral corner of valve.

Dimensions

MMF 36804 (VV): length 14.8 mm, width 27.7 mm;

MMF 36810 (DV): length 17.1 mm, specimen width 26.8 mm; estimated complete width 30.8 mm;

MMF 44968 (DV): length 18.6 mm, width 28.8 mm.

Discussion

Lack of knowledge about interior details of the ventral valve prevents conclusive identification of this species as either *Platymena* or *Glyptomena*. In establishing both genera, Cooper (1956, p.882) commented upon differences between them, remarking on the flatness of the dorsal valve and thickened marginal region in *Platymena*. The delicate cardinalia and socket ridges, and weakly developed to barely perceptible septa in the dorsal muscle field are more reminiscent of *Glyptomena*, and although no dorsal valve exteriors are known for the Gunningbland species, the sole internal mould seems to suggest a weakly concave (rather than planar) profile. However, the presence of a relatively prominent subperipheral rim is more characteristic of *Platymena*, to which this species is tentatively assigned.

Distribution

Gunningbland Formation (upper part) in vicinity of Gunningbland village, between Parkes and Bogan Gate, central west NSW; late Eastonian (Ea3-4) i.e. Katian.

Superfamily Plectambonitoidea Jones, 1928
Family Leptellinidae Ulrich and Cooper, 1936
Subfamily Leptellininae Ulrich and Cooper, 1936

Shlyginia Nikitin and Popov, 1983

Type species: *Shlyginia declivis* Nikitin and Popov, 1983

Remarks

In addition to describing *S. printhiensis* from Molong, NSW, the first species of *Shlyginia* known from outside Kazakhstan, Percival (in Percival et al., 2001) reviewed all six species previously attributed to this genus. All are similar with respect to general characteristics of the dorsal valve interior, whereas there is a wide variation in the size and disposition of the ventral muscle field. The type species, *S. declivis*, has a widely divergent ventral muscle field extending to about one-third valve length (Nikitin and Popov 1983, pl. 3, fig. 4; Cocks and Rong 2000, fig. 208, 3b – same specimen). In *Shlyginia fragilis* (Rukavishnikova, 1956) the ventral muscle field extends for about one-third valve length (Rukavishnikova 1956, pl. 2, fig. 18; Popov *et al.* 2002, pl. 6, figs 22, 25). *Shlyginia extraordinaria* (Rukavishnikova, 1956) has a very large ventral muscle field extending beyond mid valve length, in which the muscle impressions are conjoined medially for much of their length (Popov *et al.* 2000 pl. 3, fig. 19; Popov and Cocks 2006, pl. 4 figs 22-23). The ventral muscle field of *S. perplexa* Nikitin and Popov, 1996 is much reduced, occupying no more than one-quarter to one-fifth valve length (Nikitin and Popov 1996, fig. 4 F-G). The NSW species *S. printhiensis* has a ventral muscle scar confined to the posterior third of the valve, whereas in the new species described below, the ventral muscle field just reaches (but never exceeds) half valve length.

Excluded from *Shlyginia* is *S. solida* Nikitin and Popov, 1984; the sturdy, apparently tubular dorsal

Locality

All three known specimens from sandstones in upper Gunningbland Formation on "Currajong Park", Gunningbland at locality L51 [see Percival 1979a for full details].

Description

Transverse auriculate shell with maximum width at hingeline; lateral and anterior margins broadly rounded; profile apparently weakly concavo-convex, with median ventral fold; periphery of both valves dorsally geniculated. Length:width ratio 0.53 (ventral valve), 0.56 (dorsal valve). Ornament unequally parvicostellate, with 2-3 finer costellae separating relatively strongly accentuated costellae; very fine crowded concentric filae are just visible interstitially between costellae; three faint oblique rugae developed on posterolateral flanks.

Ventral valve with low apsacline interarea, and narrow pseudodeltidium extending entire height of interarea. Interior details of ventral valve unknown.

Dorsal valve interarea very low, orthocline to weakly anacline, with small, apparently complete chilidium. Delicate cardinal process lobes are continuous laterally with fine, broadly divergent socket ridges; notothyrial platform beneath cardinal process is barely thickened above valve floor, extending anteriorly as a short, low median ridge; transmuscle septa very poorly developed. Musculature and mantle canals not deeply impressed; muscle field extends no more than one-third valve length. Broadly rounded subperipheral rim slightly raised above dorsal valve floor, geniculate dorsally in anterior portion; width of subperipheral rim greatest in posterolateral corner of valve.

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Discussion

Lack of knowledge about interior details of the ventral valve prevents conclusive identification of this species as either *Platymena* or *Glyptomena*. In establishing both genera, Cooper (1956, p.882) commented upon differences between them, remarking on the flatness of the dorsal valve and thickened marginal region in *Platymena*. The delicate cardinalia and socket ridges, and weakly developed to barely perceptible septa in the dorsal muscle field are more reminiscent of *Glyptomena*, and although no dorsal valve exteriors are known for the Gunningbland species, the sole internal mould seems to suggest a weakly concave (rather than planar) profile. However, the presence of a relatively prominent subperipheral rim is more characteristic of *Platymena*, to which this species is tentatively assigned.

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Excluded from *Shlyginia* is *S. solida* Nikitin and Popov, 1984; the sturdy, apparently tubular dorsal

median septum of this species indicates that it belongs in *Mabella* Klenina, 1984. Also referred to *Mabella* on this same criterion is *Dulankarella namasensis* Klenina, 1984 (and its synonym *D. subquadrata* Klenina, 1984), previously assigned to *Shlyginia* by Nikitin and Popov (1996).

***Shlyginia rectangularis* sp. nov.**

Fig. 9 A-X

Diagnosis

Transversely rectangular, dorsoventrally compressed *Shlyginia* with distinctive V-shaped incision at posterolateral extremities of ventral valve; muscle scar extending to midlength of ventral valve; 2-3 pairs of discrete nodes present on platform of dorsal valve laterally between muscle field and peripheral rim.

Etymology

Referring to rectangular outline.

Material

Holotype MMF 44959 (ventral valve); paratypes include MMF 44947 (conjoined valves), MMF 44948 (ventral valve), MMF 44949 (dorsal valve), MMF 44950 (dorsal valve), MMF 44951 (conjoined valves), MMF 44952 (ventral valve), MMF 44953 (ventral valve), MMF 44954 (ventral valve), MMF 44955 (dorsal valve), MMF 44956 (dorsal valve), MMF 44957 (ventral valve), MMF 44958 (dorsal valve), MMF 44960 (dorsal valve), and MMF 44961 (dorsal valve). All specimens are silicified.

Localities

Type locality is L142 (Paling Yards Creek section at "The Ranch", Bowan Park), in Quondong Limestone, Bowan Park Subgroup; also found in same horizon at L138 ("Quondong", Bowan Park, east of Cudal); occurs also at L24 (Licking Hole Creek area, Walli) in Trilobite Hill Limestone Member of Vandon Limestone, upper Cliefden Caves Limestone Subgroup; and at L143 in upper Billabong Creek Limestone, from outcrop in Billabong Creek at road crossing, south of Gunningbland [full details of these localities are given by Percival 1991].

Description

Transversely rectangular shells with long, straight hingeline, lateral margins nearly straight and parallel to slightly convergent anteriorly, with broadly rounded anterior margin. Dorsoventrally compressed, planoconvex profile; maximum convexity close to anterior margin; ventral valve flattened medially, becoming broadly sulcate anteromedially in largest specimens. Valve length between 4.4 and 8.8 mm, width 5.7 to 13.7 mm; length:width ratios in 13 specimens ranging from 0.55-0.69, with average of 0.61; maximum width at hingeline with slightly auriculate, posterolateral extremities in best preserved specimens, otherwise widest in posterior third of shell. Ornament finely unequally parvicostellate, very faintly impressed except for accentuated costellae, rarely lamellose peripherally in largest specimens. Ventral interarea low, apsacline, with upper third of delthyrium covered by small deltidium; dorsal interarea much lower, anacline, with very fine, paired chilidial plates flanking trifid cardinal process.

Ventral valve interior: teeth small, unsupported by dental plates. Muscle field moderately to deeply impressed, adductor scars confined to a small median depression deep within delthyrium; diductors much larger, moderately divergent anteriorly, distinctly separated medially by fine ridge, and extending to mid valve length. Mantle canals of lemniscate type, with moderately strongly impressed *vascula media* and weaker *vascula genitalia* (sometimes not visible). Narrow, linear median depression extending from muscle field nearly to anterior margin of valve appears to exactly coincide with dorsal median septum.

Dorsal valve interior: Anterior edge of hingeline thickened towards lateral extremities. Cardinalia typically leptellinine, trifid with prominent central ridge flanked by finer oblique lateral ridges, supported on a low thickened notothyrial platform. Socket ridges short, bladelike and pointed oblique to hingeline. Muscle field well defined by bounding ridges extending anteriorly from ends of socket ridges; muscle field bisected obliquely by low ridges that may represent proximal traces of *vascula media*. Solid ridge-like median septum, not expanding anteriorly, is separated from front of notothyrial platform by shallow depression; septum rises sharply and extends to approximately 0.8-0.85 valve length to merge with edge of barely undercut platform margin. Two to three pairs of discrete nodes are present on platform lateral to muscle field. Mantle canals beyond muscle field rarely impressed, possibly saccate.

Dimensions

Holotype MMF 44959 (ventral valve) is 7.2 mm long and 11.5 mm wide. Paratype MMF 44947 (conjoined valves) measures 7.4 mm in length, 12.1 mm in width, and 2.0 mm in thickness. Lengths of 12 other paratypes range from 4.4 mm to 8.8 mm, with most between 5.0-7.5 mm long; widths of 13 paratypes range from 5.7 mm to 13.7 mm, most are 9-12 mm wide. There is no appreciable difference

median septum of this species indicates that it belongs in *Mabella* Klenina, 1984. Also referred to *Mabella* on this same criterion is *Dulankarella namasensis* Klenina, 1984 (and its synonym *D. subquadrata* Klenina, 1984), previously assigned to *Shlyginia* by Nikitin and Popov (1996).

***Shlyginia rectangularis* sp. nov.**

Fig. 9 A-X

Diagnosis

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Etymology

Referring to rectangular outline.

Material

Holotype MMF 44959 (ventral valve); paratypes include MMF 44947 (conjoined valves), MMF 44948 (ventral valve), MMF 44949 (dorsal valve), MMF 44950 (dorsal valve), MMF 44951 (conjoined valves), MMF 44952 (ventral valve), MMF 44953 (ventral valve), MMF 44954 (ventral valve), MMF 44955 (dorsal valve), MMF 44956 (dorsal valve), MMF 44957 (ventral valve), MMF 44958 (dorsal valve), MMF 44960 (dorsal valve), and MMF 44961 (dorsal valve). All specimens are silicified.

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Type locality is L142 (Paling Yards Creek section at "The Ranch", Bowan Park), in Quondong Limestone, Bowan Park Subgroup; also found in same horizon at L138 ("Quondong", Bowan Park, east of Cudal); occurs also at L24 (Licking Hole Creek area, Walli) in Trilobite Hill Limestone Member of Vandon Limestone, upper Cliefden Caves Limestone Subgroup; and at L143 in upper Billabong Creek Limestone, from outcrop in Billabong Creek at road crossing, south of Gunningbland [full details of these localities are given by Percival 1991].

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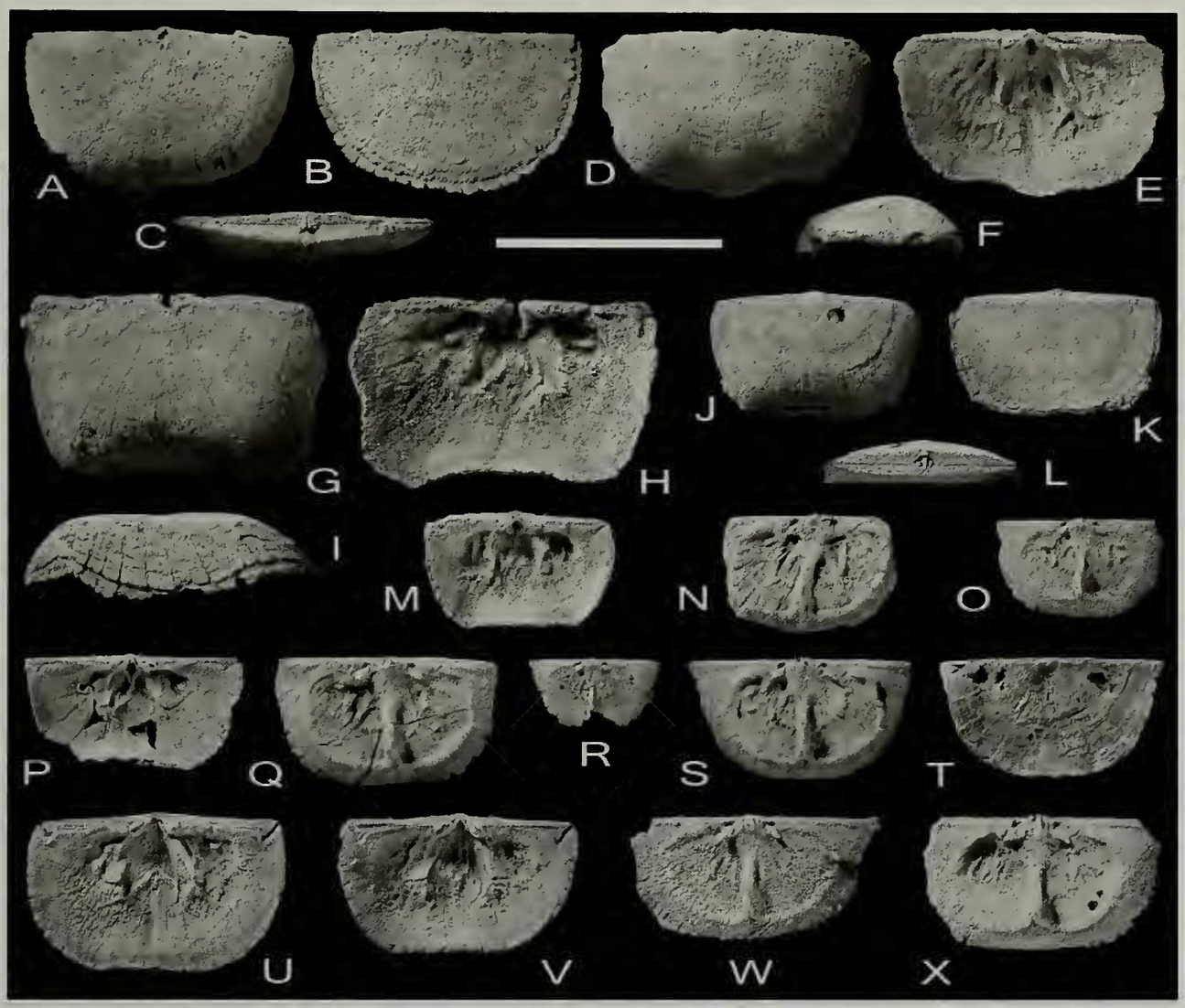
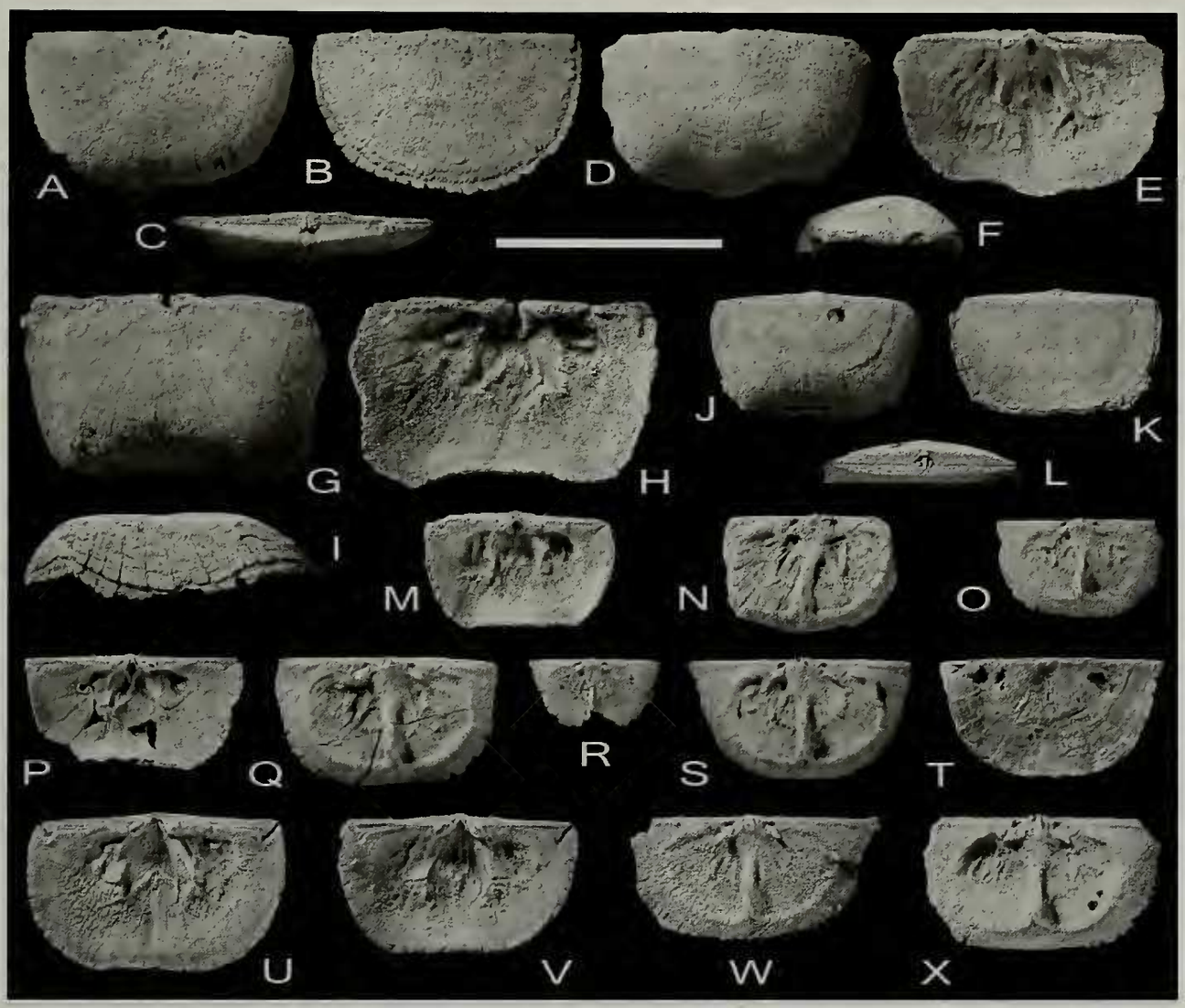


Figure 9. ***Shlyginia rectangularis*** **sp. nov. A – C: exterior of conjoined valves, ventral and dorsal respectively, and posterior profile (dorsal valve uppermost), MMF 44947. D – F: exterior, interior and lateral profile (posterior to left) of ventral valve, MMF 44952. G – I: exterior, interior and anterior profile of ventral valve, MMF 44948. J – L: conjoined valves, ventral and dorsal exteriors and posterior profile (ventral valve uppermost) respectively, MMF 44951. M: interior of ventral valve, MMF 44953. N: interior of dorsal valve, MMF 44950. O: interior of dorsal valve, MMF 44955. P: interior of ventral valve, MMF 44954. Q: interior of dorsal valve, MMF 44958. R: interior of juvenile dorsal valve, MMF 44956. S – T: interior and exterior of dorsal valve, MMF 44960. U: interior of ventral valve, holotype MMF 44959. V: interior of ventral valve, MMF 44957. W: interior of dorsal valve, MMF 44961. X: interior of dorsal valve, MMF 44949. Scale bar represents 1 cm. A – C, G – I, N, X from L24, Trilobite Hill Limestone Member of Vandon Limestone, upper Cliefden Caves Limestone Subgroup at Licking Hole Creek near Walli; D – F, J – L, M, O, P, R from L135 (east of Copper Mine Creek, near Cliefden Caves), in Trilobite Hill Limestone Member of Vandon Limestone, upper Cliefden Caves Limestone Subgroup; Q, U, V from L142 (Paling Yards Creek section at "The Ranch", Bowan Park), in Quondong Limestone, Bowan Park Subgroup; S – T from L138 ("Quondong", Bowan Park, east of Cudal), Quondong Limestone, Bowan Park Subgroup; W from L143, upper Billabong Creek Limestone at Billabong Creek road crossing south of Gunningbland.**

between measurements of dorsal and ventral valves.

Discussion

Two distinctive morphological features – the V-shaped incisions at the posterolateral extremities of the ventral valve interior, and the presence of nodes on the platform lateral to the dorsal muscle field – serve to distinguish *S. rectangularis* from all other known



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between measurements of dorsal and ventral valves.

Discussion

Two distinctive morphological features – the V-shaped incisions at the posterolateral extremities of the ventral valve interior, and the presence of nodes on the platform lateral to the dorsal muscle field – serve to distinguish *S. rectangularis* from all other known

species of *Shlyginia*. The function of the V-shaped incisions is not clear, although one likely explanation is that they interlock with corresponding thickened parts of the hingeline in the dorsal valve to strengthen articulation of the valves when open. Containment of the dorsal muscle field by bounding ridges is another characteristic feature of *S. rectangularis*. The large ventral muscle field of the new species is comparable only with that of *S. extraordinaria* which also has a similar trapezoidal outline, being noticeably widest at the hingeline. However, the dorsal interior of *S. extraordinaria*, illustrated by Popov *et al.* (2000, pl. 3, figs 18-20) and Popov and Cocks (2006, pl. 4, figs 25-26), exhibits a much less robust median septum than does *S. rectangularis*. Unlike both *S. extraordinaria* and the other NSW species *S. printhiensis*, the new species lacks a well-defined marginal rim in the ventral valve; the median septum of *S. rectangularis* is also relatively much longer than that of *S. printhiensis*.

Distribution

Limestones of mid-Eastonian (Ea2) age, equivalent to basal Katian, throughout the Macquarie Arc in central NSW.

Order Pentamerida Schuchert and Cooper, 1931
Suborder Syntrophiidina Ulrich and Cooper, 1936
Superfamily Camerelloidea Hall and Clarke, 1895
Family Parastrophinidae Schuchert and LeVene, 1929

***Parastrophina* Schuchert and LeVene, 1929**

Type species: *Atrypa hemiplicata* Hall, 1847

***Parastrophina* sp.**

Fig. 10 A-G

Material

One fragmentary dorsal valve (MMF 44962) from L147, three ventral valves (all incomplete) MMF 44963-44965 from L24, and one partial ventral valve (MMF 44966) from L138 (doubtfully attributed).

Localities

Vandon Limestone (Trilobite Hill Limestone Member), Cliefden Caves Limestone Subgroup at locality L24, Licking Hole Creek, Walli; Checkers Member of Regans Creek Limestone at locality L147, "Red East", Regans Creek southeast of Cargo; ventral valve from Quondong Limestone, Bowan Park Subgroup at locality L138, "Quondong", Bowan Park, east of Cudal is doubtfully attributed [full details of localities given by Percival (1991)].

Description

Ventral valve: convex, smooth externally on posterior and lateral flanks, with shallow sulcus developed anteriorly, bearing 2-3 costae to form a weakly plicate anterior margin; internally with large subparallel dental plates extending to valve floor, bounding narrow, deep, parallel-sided sessile spondylium extending to approximately two-thirds valve length, supported anteriorly by very short median septum which barely extends beyond anterior edge of spondylium.

Dorsal valve: smooth, convex posteriorly with prominent umbo (anterior part of valve not preserved); cardinal process lacking; deep narrow septalium present bounded by thin walls anteriorly convergent on to low thin median septum that extends anteriorly for an unknown distance; alate plates present.

Dimensions

Dorsal valve MMF 44962 L= 7.5 mm (incomplete), width estimated at 20 mm.

Ventral valve MMF 44963 L= 4.5 mm, full width unknown.

Ventral valve MMF 44966 W= 12.5 mm (incomplete), estimated width about 20 mm.

Discussion

The available material, although incomplete, is assigned to *Parastrophina* rather than to the externally similar *Camerella* on the basis of the presence of alate plates in the sole dorsal valve. The ventral valve from the Quondong Formation at Bowan Park has the same smooth exterior, at least posteriorly, and similar dimensions to the other specimens. However, it is only doubtfully attributed to the same species, as evidence that the spondylium is supported above the valve floor at the front is lacking (this part of the shell being broken away). Alternatively, if the dental plates rest unsupported on the valve floor then this specimen may be better placed in *Stenocamara* Cooper, 1956.

Numerous species of *Parastrophina* have been described, from North America (Cooper, 1956), Kazakhstan (Sapelnikov and Rukavishnikova 1975; Nikitin et al. 1996; Popov et al. 2002; Nikitin et al. 2006) and elsewhere, but it is difficult to make accurate comparisons between those (particularly when described from serial sections) and the sparse and incomplete silicified material from NSW.

Distribution

Rare in limestones of early Eastonian (Ea2) age,

species of *Shlyginia*. The function of the V-shaped incisions is not clear, although one likely explanation is that they interlock with corresponding thickened parts of the hingeline in the dorsal valve to strengthen articulation of the valves when open. Containment of the dorsal muscle field by bounding ridges is another characteristic feature of *S. rectangularis*. The large ventral muscle field of the new species is comparable only with that of *S. extraordinaria* which also has a similar trapezoidal outline, being noticeably widest at the hingeline. However, the dorsal interior of *S. extraordinaria*, illustrated by Popov *et al.* (2000, pl. 3, figs 18-20) and Popov and Cocks (2006, pl. 4, figs 25-26), exhibits a much less robust median septum than does *S. rectangularis*. Unlike both *S. extraordinaria* and the other NSW species *S. printhiensis*, the new species lacks a well-defined marginal rim in the ventral valve; the median septum of *S. rectangularis* is also relatively much longer than that of *S. printhiensis*.

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Discussion

The available material, although incomplete, is assigned to *Parastrophina* rather than to the externally similar *Camerella* on the basis of the presence of alate plates in the sole dorsal valve. The ventral valve from the Quondong Formation at Bowan Park has the same smooth exterior, at least posteriorly, and similar dimensions to the other specimens. However, it is only doubtfully attributed to the same species, as evidence that the spondylium is supported above the valve floor at the front is lacking (this part of the shell being broken away). Alternatively, if the dental plates rest unsupported on the valve floor then this specimen may be better placed in *Stenocamara* Cooper, 1956.

Numerous species of *Parastrophina* have been described, from North America (Cooper, 1956), Kazakhstan (Sapelnikov and Rukavishnikova 1975; Nikitin et al. 1996; Popov et al. 2002; Nikitin et al. 2006) and elsewhere, but it is difficult to make accurate comparisons between those (particularly when described from serial sections) and the sparse and incomplete silicified material from NSW.

Distribution

Rare in limestones of early Eastonian (Ea2) age,

equivalent to earliest Katian, in the Macquarie Arc of central NSW.

***Eoanastrophia* Nikiforova and Sapelnikov, 1973**
Type species: *Eoanastrophia antiquata* Nikiforova and Sapelnikov, 1973

***Eoanastrophia*? sp.**
Fig. 10 H-I

Material

One specimen, an incomplete dorsal valve, MMF 44967.

Locality

Quondong Limestone, Bowan Park Subgroup at locality L138, "Quondong", Bowan Park, east of Cudal [full details of locality given by Percival (1991)].

Description

Dorsal valve entirely costate with angular ribs, occasionally with intercalated costellae; internally with short septalium supported on long high median septum; very small sockets; crura present (preserved only on left-hand side of specimen); no cardinal process. Ventral valve not available for description.

Dimensions

Specimen 11.4 mm long and 9.4 mm wide (both dimensions incomplete).

Discussion

Similarly strongly costate parastrophinid genera include *Eoanastrophia* Nikiforova and Sapelnikov, 1973 and *Maydenella* Laurie, 1991. The latter genus, from the late Middle Ordovician Upper Cashions Creek Limestone in Tasmania, has a sessile septalium resting on the valve floor that is bounded by long subparallel hinge plates, whereas in *Eoanastrophia* the hinge plates converge onto a septum which

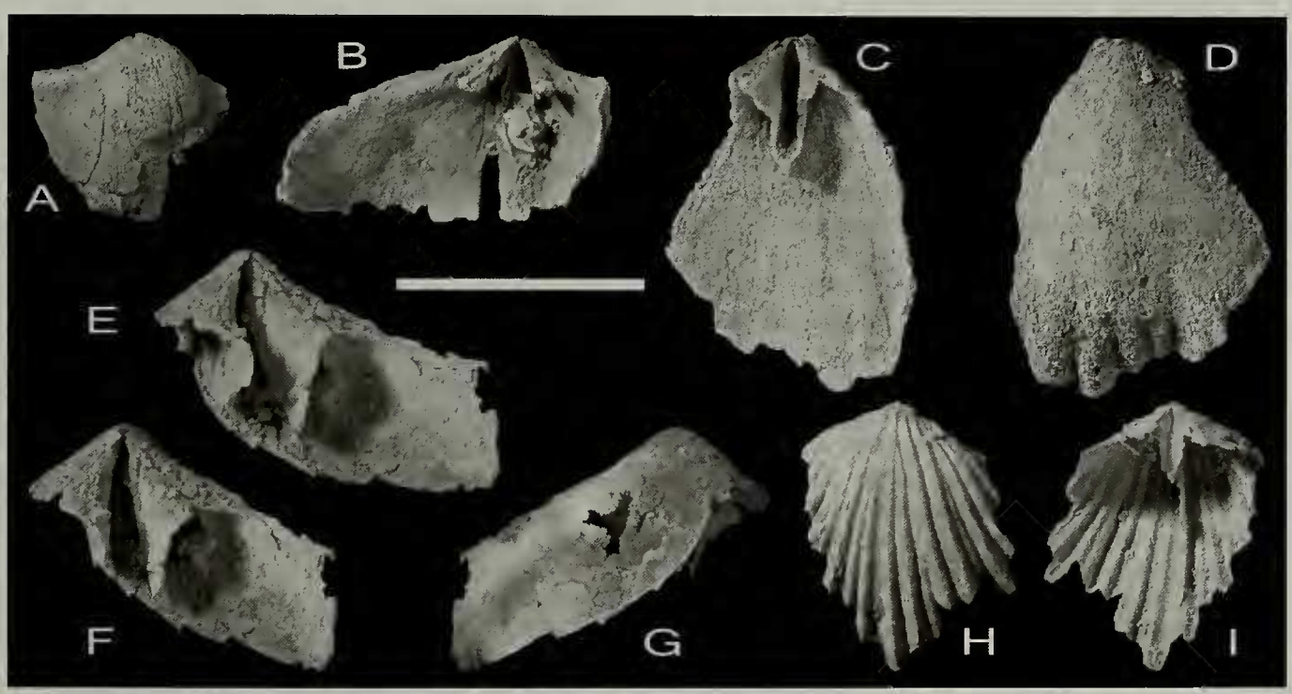

Figure 10. A – G: *Parastrophina* sp. A – B: exterior and interior of partial dorsal valve, MMF 44962, specimen broken during photography; from Checkers Member of Regans Creek Limestone at locality L147, "Red East", Regans Creek southeast of Cargo. C – D: interior and exterior of partial ventral valve, MMF 44963; from Vandon Limestone (Trilobite Hill Limestone Member), Cliefden Caves Limestone Subgroup at locality L24, Licking Hole Creek, Walli. E – G: two interior views (the first slightly tilted to show dental plates extending to valve floor) and exterior of ventral valve, MMF 44966, doubtfully attributed to this species; from Quondong Limestone, Bowan Park Subgroup at locality L138, "Quondong", Bowan Park, east of Cudal. Scale bar representing 1 cm applies to all specimens in this figure.
H – I: *Eoanastrophia*? sp., exterior and interior of dorsal valve (interior view slightly tilted to better show septum supporting septalium), MMF 44967, from Quondong Limestone, Bowan Park Subgroup at locality L138, "Quondong", Bowan Park, east of Cudal.

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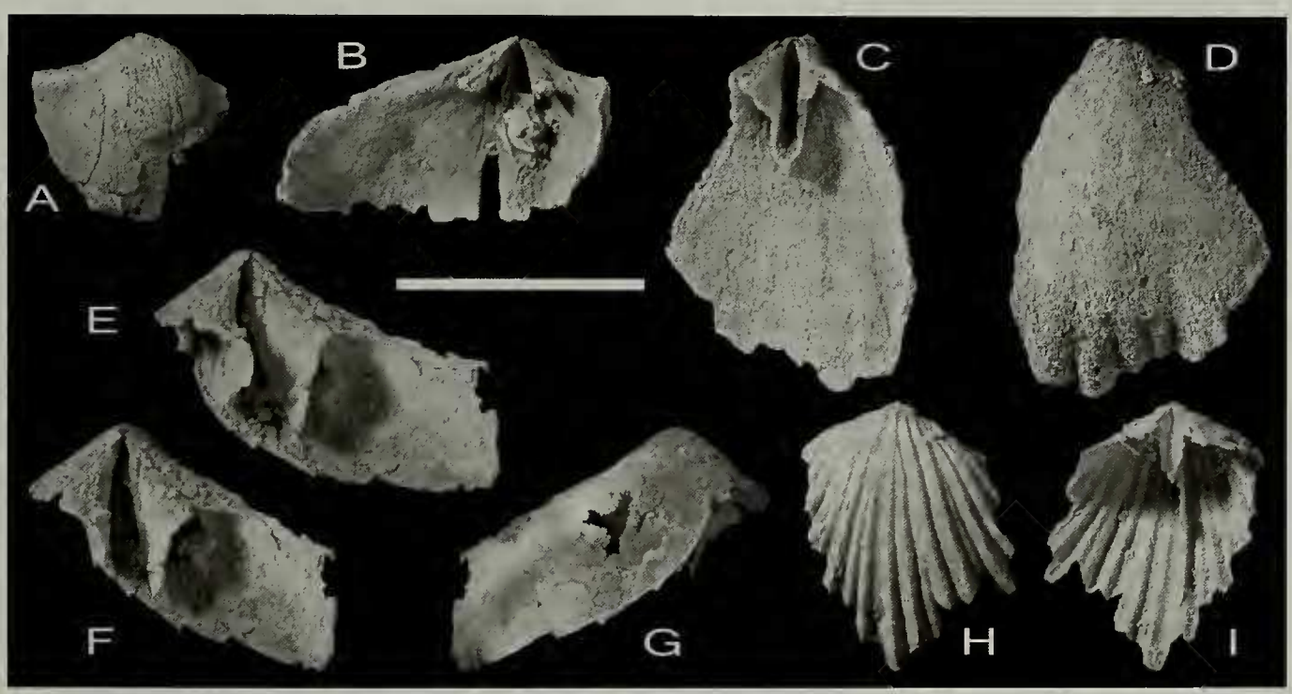

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